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Summary

The phoronids Phoronis psammophilia Cori and Phoronopsis albomaculata Gilchrist are recorded for the first time from both South Australia (Spencer Gulf) and New Caledonia (Nouméa lagoon), and the latter for the first time from New Zealand. A diagnosis is given for each species, as well as for Phoronis australis Haswell. The distribution of all three species in the Pacific Ocean, Southern and Western Australian waters is detailed.

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Of the ten known species of Phoronida, all have representative populations in the Pacific Ocean and seven have been recorded in Australian waters (Emig *et al.* 1977; Emig 1982a, b). Recent benthic surveys of Spencer Gulf and Nouméa lagoon have resulted in the first records of *Phoronis psammophila* and *Phoronopsis albomaculata* from South Australia and New Caledonia; the new material is listed below, together with details of the collecting stations. Previously unidentified material from New Zealand in the collection of Portobello Marine Laboratory proves upon reexamination to be the first New Zealand record of *Phoronopsis albomaculata.* In addition, examination of material of *Phoronis australis* in the South Australian Museum led to additional locality records of this species in Western Australia and Queensland. The Pacific occurrence of all three species is discussed below, and a brief diagnosis given of each.

Phoronis australis Haswell

Phoronis australis Haswell, 1883: 606.
Phoronis buskii McIntosh, 1888: 1.

Distribution in the Pacific Ocean (Fig. 1).

Japan : 3. Misaki (Ikeda 1902, 1903); 4. Kyushyu (Ishihawa 1977), Kii Peninsula (Uchida 1979). *China* : 6. Amoy, Qingdao (Wu & Ruiping 1980; Emig 1982a b). *Philippines* : 7. (McIntosh 1888; Cori 1939). *Vietnam* : 8. Nhatrang Bay (Kasyanov & Radashevsky 1987). *Australia* : 17. Waterman Bay, W. Aust., (coll. South Australian Museum; Fig. 1); 10. Southport, Queensland (coll. South Australian Museum; Fig. 1), Moreton Bay, Queensland (Emig 1977); 18. Houtman Abrolhos Is., W. Aust. (Emig 1982b); 12. Sydney, N.S.W. (Haswell 1883; Ponder 1971; Emig *et al.* 1977).

Diagnosis

Burrowing in tube-wall of cerianthids, generally of the genus *Cerianthus.* From the intertidal zone to 36 m depth.

Length in extension up to 200 mm, 2-5 mm in diameter. Colour in life: body pink; anterior body part and lophophore transparent or purple to black. Lophophore spiral with 2.5 to 3.5 coils on each side, 5-16 mm in length, 600-1 000 tentacles. Nephridia with two funnels (anal large, oral small), an ascendant branch only, nephridiopore opening on nephridial ridge at level of anus. Two giant nerve fibres (left one 5-13 μm in diameter; right one 3-13 μm in diameter). Longitudinal muscle bundles of bushy type; arrangement of longitudinal muscle bundles relative to four sub-divisions of metacoelom formed by mesenteries (i.e. clockwise left oral, right oral, right anal, left anal sub-divisions) represented by conventional formula of Selys-Longchamps (1907); the general formula is:

$$[43\text{-}87]\ \frac{14\text{-}29 \mid 13\text{-}27}{4\text{-}17 \mid 5\text{-}17} \text{ and the mean formula is}$$

$$64 = \frac{22 \mid 22}{11 \mid 9}.$$

Sexual reproduction hermaphroditic; embryos brooded in lophophoral cavity on mucous cord secreted by nidamental glands of type B (*i.e.* restricted to floor of lophophoral concavity with an extension along coils of lophophore on inner surface of tentacles and associated with two embryo masses); lophophoral organs small. Asexual reproduction by transverse fission.

Larva: unknown.

Remarks

The burrowing habits of *P. australis* are characteristic. The species lives in the tube-wall of cerianthid species, mainly of *Cerianthus.* No ecological data were available on the individuals. The specimens collected in Australian waters appear to have a higher number of longitudinal muscle bundles than those examined in Atlantic and Indian waters (Table 1).

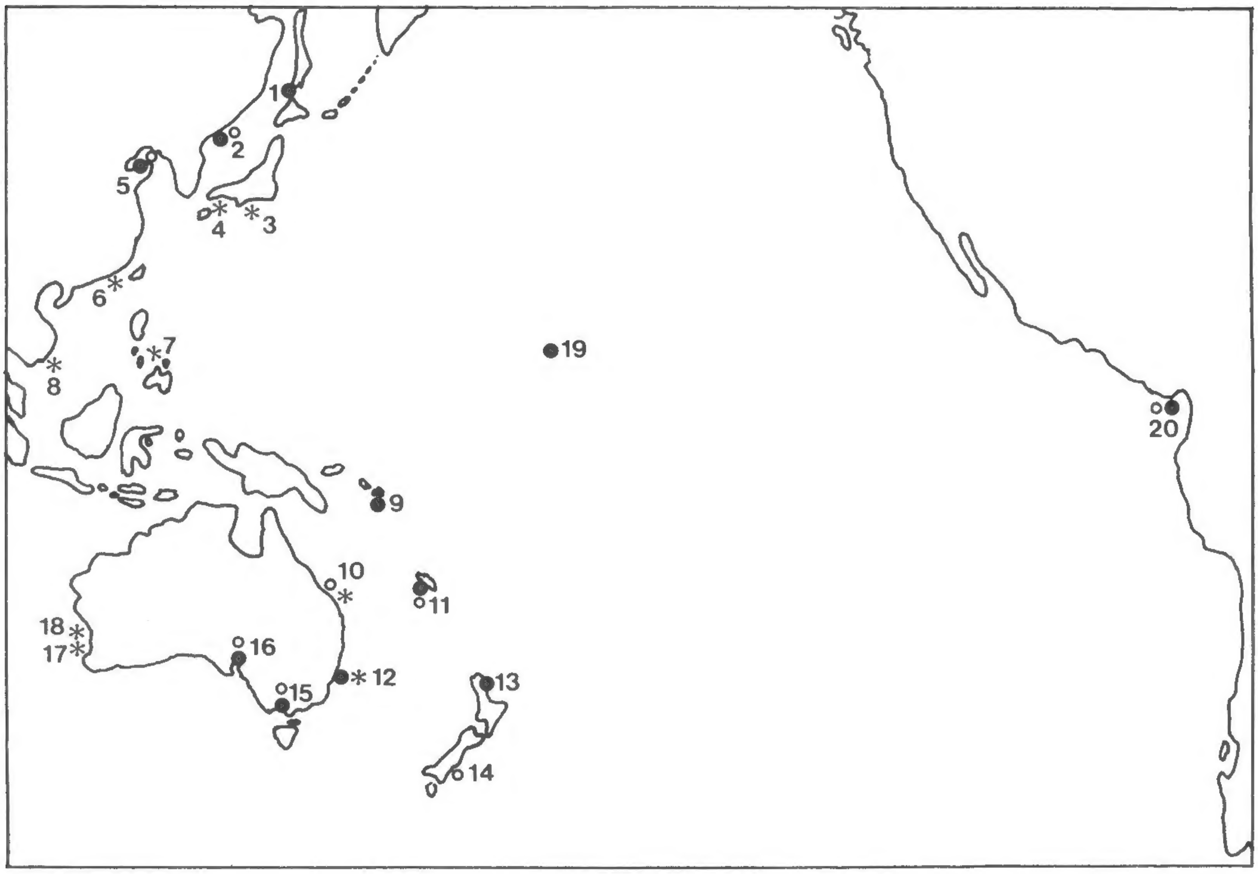

FIGURE 1. Occurrences of *Phoronis australis*, *P. psammophila* and *Phoronopsis albomaculata* in the Pacific Ocean (see explanation in text for location numbers and Tables 1, 4 and 5).

TABLE 1. Longitudinal muscle formulae of *Phoronis australis* recorded in Australian locations (see Fig. 1 for locations). N = number of specimens examined.

Locality	N	Mean	General Formula	
10. Southport	5	$78 = \frac{27 \mid 26}{14 \mid 11}$	$\frac{23-30 \mid 22-27}{12-15 \mid 10-14}$	[68–84]
10. Moreton Bay	1	$65 = \frac{23 \mid 22}{13 \mid 7}$		
12. Sydney	21	$73 = \frac{25 \mid 24}{13 \mid 11}$	$\frac{20-28 \mid 19-27}{8-17 \mid 7-17}$	[60–87]
17. Waterman Bay	1	$59 = \frac{21 \mid 19}{11 \mid 8}$		
Total for species	94	$66 = \frac{23 \mid 22}{12 \mid 9}$	$\frac{17-35 \mid 14-27}{4-17 \mid 5-19}$	[43–87]

Phoronis psammophila Cori

Phoronis psammophila Cori, 1889: 1.
Phoronis sabatieri Roule, 1889: 195.
Phoronis architecta Andrews, 1890: 445.

Distribution in the Pacific Ocean (Fig. 1).

Russia Far East: 1. Sakhalin (Emig 1984; Emig & Golikov 1990); 2. Poss'yet Bay, Mordinov Gulf (Emig 1984; Emig & Golikov 1990). *China*: 5. Changshan Is., Dalni, Potonoman (Emig 1984). *Solomon Is.*: 9. (Emig 1977). *Australia*: 12. Cabbage Tree Basin, N.S.W. (Rainer & Fitzhardinge 1981); 15. Port Phillip Bay, Western Port, Victoria (Emig *et al.* 1977); 16. Spencer Gulf, S. Aust. (coll. South Australian Museum; Fig. 2). *New Caledonia*: 11. Nouméa lagoon (coll. Emig; Fig. 3). *New Zealand*: 13. Ranganna Bay, Doubtless Bay (coll. D. P. Gordon); 13. Howick, Whangateau Harbor, Waitemata, Jellicoe (Jillett 1971; Gordon & McKnight 1983; coll. D. Gordon). *USA-Hawaii*: 19. Oahu (Emig 1977; Emig & Bailey-Brock 1987); 19. Midway (Sorden 1983). *Panama*: 20. (Emig 1982a).

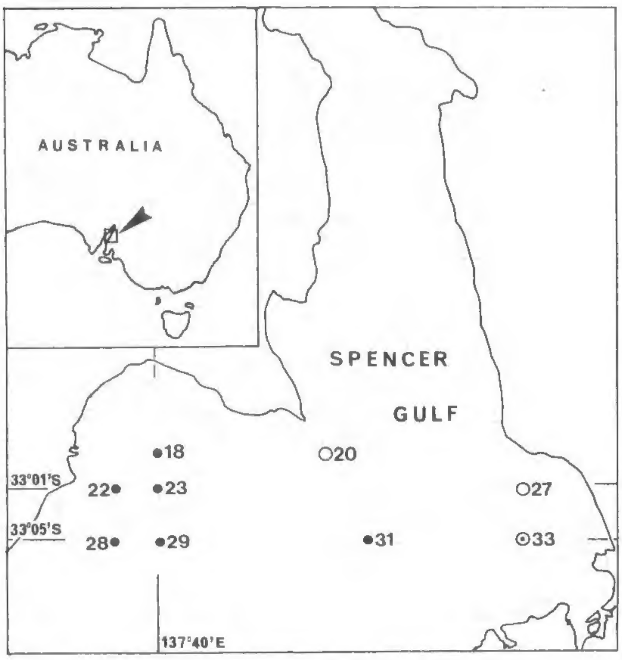

FIGURE 2. Map of the stations at which phoronid species have been recorded in Spencer Gulf (numbers correspond to station numbers of Table 2).

Diagnosis

Embedded vertically in soft sediments, generally sandy to muddy, or covered by seagrass beds. From the intertidal zone down to 52 m depth.

Length in extension up to 190 mm, diameter 0.5-2 mm. Colour in life: body pink; lophophore transparent with white (occasionally yellow, green or red) pigment spots. Lophophore horseshoe-shaped with ends turned medially. Tentacles up to 190, length 1.5-2.5 mm. Nephridia with single funnel, descending and ascending branch, nephridiopore on anal papilla opening below anus. Single giant nerve fibre, on left side, 7-27 μm in diameter, very thin nerve fibre rarely present on right side. Longitudinal muscle bundles of feathery type; general formula is:

$$[24\text{-}53]\ \frac{7\text{-}19 \mid 7\text{-}18}{4\text{-}11 \mid 4\text{-}11},\ \text{mean formula is } 35 = \frac{12 \mid 11}{6 \mid 6}.$$

Sexual reproduction dioecious; females brooding embryos in single mass in lophophoral cavity through nidamental glands of type C (*i.e.* formed by fusion of inner row of lophophore tentacles); males with large, glandular lophophoral organs. Asexual reproduction by transverse fission.

Larva: *Actinotrocha sabatieri* Roule, 1896.

Remarks

In South Australia during the benthic survey of Spencer Gulf, *P. psammophila* was recorded at seven stations, occurring with *Phoronopsis albomaculata* only at St. 33 (Fig. 2; Table 2), at which site its density reached about 40 individuals.m^{-2}. In Cabbage Tree Basin, NSW (Rainer & Fitzhardinge 1981) (Fig. 1), *P. psammophila* was found in three locations where the salinity varies between 27.8 and 36.2% and the annual temperature range between 10.7 and 26.4°C: in stable sand flat at 0.3 m (but presence appears rather uncommon in shallower sites in this basin); in a silty sand with patches of *Posidonia australis* at 2 m depth; and in silty sand with surface detritus at 5 m depth. This last location has a much lower concentration of dissolved oxygen, which confirms the ability of this species to live in waters containing small amounts of oxygen (Emig 1982b). The associated fauna is common in many estuaries along the south-east Australian coast.

In New Zealand, *Phoronis psammophila* has been collected in the northern part of North Island, in Howick (Auckland Harbour) in a *Zostera* patch in sandy mud and sporadically in Whangateau Harbor (D. P. Gordon, personal communication); in Ranganna Bay in fine sand at 21 m (34°50′38″S, 173°14′60″E); in Doubtless Bay in fine sand at 17 m (34°56′21″S, 173°24′43″E) and in sandy mud at 52 m (34°56′21″S, 173°24′43″E). The last location is the deepest record for *P. psammophila*. In the last two locations the specimens, collected with a Smith-McIntyre grab, are sparsely distributed (2-3 individuals per haul).

In the Nouméa lagoon, New Caledonia (Fig. 3; Table 3), *P. psammophila* occurs at low density in fine to coarse sands, generally covered with a rich epibiosis, and in seagrass beds of *Halodule minervis* with *Halimeda* (St.65, 119A, 119B); its density varied from 3 to 100 individuals.m^{-2}. This species occurred

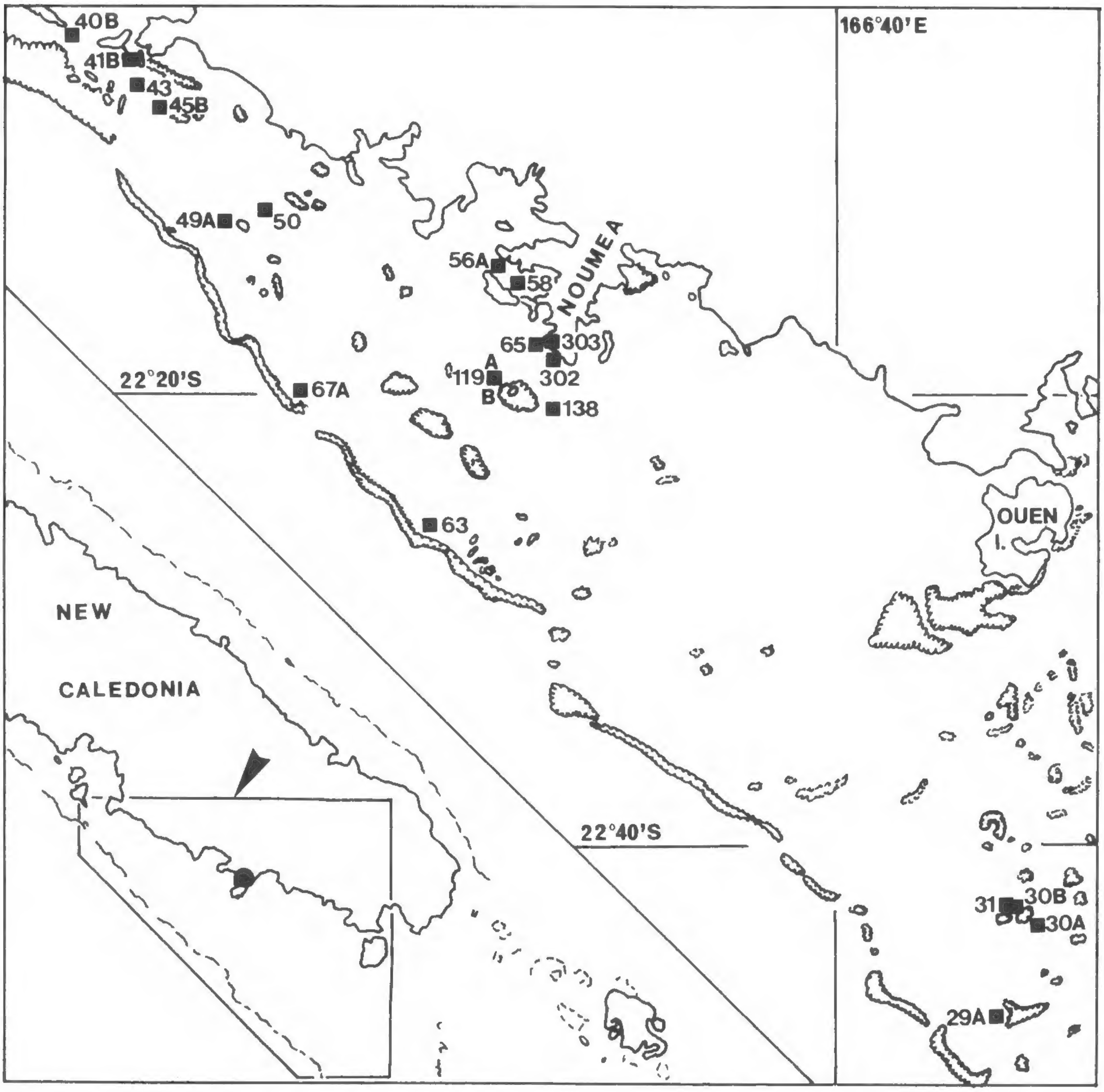

FIGURE 3. Map of the stations at which phoronid species have been recorded in the Nouméa lagoon (numbers correspond to station numbers of Table 3).

generally with one or two other phoronid species, *e.g.* *Phoronis muelleri* Selys-Longchamps, *Phoronopsis albomaculata* and/or *Phoronopsis harmeri* Pixell (Table 3). In the Anse Vata (0-2 m; St. 302) and in the Baie des Citrons (2-5m; St.303, 65), *Phoronis psammophila* occurs with *Phoronopsis harmeri* at very shallow depth.

The various populations of *Phoronis psammophila* cannot be characterized by the formulae of their longitudinal muscles (Table 4), for large variations occur within the populations, and within and between geographical areas. No relationship could be established with environmental factors.

Phoronopsis albomaculata Gilchrist

Phoronopsis albomaculata Gilchrist, 1907: 152.

Distribution in the Pacific Ocean (Fig. 1).

Russia: 2. Peter-the-Great Bay, Poss'yet Bay (Emig & Golikov 1990). *Australia:* 10. Moreton Bay, Queensland (Emig 1977; Emig *et al.* 1977); 15. Port Phillip Bay, Western Port, Victoria (Emig *et al.* 1977); 16. Spencer Gulf, S. Aust. (coll. South Australian Museum; Fig. 2). *New Caledonia*: 11. Nouméa lagoon (coll. C. C. Emig, B. A. Thomassin; Fig. 3). *New Zealand*: 14. Otago, Portobello (Rainer 1981; coll. Portobello Marine Laboratory). *Panama*: 20. (Emig 1982a).

TABLE 2. Records of *Phoronis psammophila* and *Phoronopsis albomaculata* in Spencer Gulf (see map in Fig. 2) and of *Phoronis australis* in Australian waters. Surface per grab haul is 0.1 m^2. SAM = South Australian Museum.

St.	Depth (in m)	Sand	Number of individuals per grab haul Nov. 85	Feb. 86	Aug. 86	Feb. 87	Sept. 87	Reg. No. SAM.L. . .
Phoronis psammophila								
18	10	fine					3	513
22	10	fine			1			503
23	12	fine			2		2 1	504, 514, 515
28	12	medium					1	516
29	13	fine					1	505
31	8	coarse					1	517
Phoronopsis albomaculata								
20	22	coarse					1	526
27	7	fine		6 7 6	1 2 1		2 4 4 11	521-525 527-530
Phoronis psammophila and *[Phoronopsis albomaculata]*								
33	5	very fine	2	2 1	1 4 1	1	1 3+[2]	506-512 518-520 [531]

Phoronis australis:
- Waterman Bay (W Australia, 31°51′S, 115°45′E), Coll. Noel Morrissy, Reg. No. SAM.TL 7294
- Southport (Queensland), Reg. No. SAM.TL 6605

TABLE 3. Records of Phoronida in the Nouméa lagoon (collected by B. A. Thomassin and C. C. Emig) (see map in Fig. 3); the data in italics represent individuals.m^{-2}. In St.119A, 119B, and 138, the percentage of organic carbon is 0.3-0.35 FF = fine fraction of the sediment (<63 μm). SAM = South Australian Museum.

St.	Depth (in m)	*Phoronis* *muelleri*	*psammophila*	*Phoronopis* *albomaculata*	*harmeri*	Sand	%FF	Reg. No. SAM.L. . .
29A	24	*5*	*5*					
30A	12			2				
30B	6		1					643
31	16		2					
40B	17				1	fine muddy		
41B	6	*3*		*9*	*3*			652 649 641
43	21	8	1			coarse	11	
45B	13			1				
49A	10		2	3		coarse	3	650 644
50	26	1	3		5	coarse	4	653 645 642
56A	15	*20*				fine muddy		
58	10	2				sandy mud		
63	11		*3*	*3*		fine	4	
65	5		2	6		coarse	5	651 646
67A	14	*5*				coarse fine		
119A	6		*40*		*50*	coarse		654 647
119B	6		*40*		*40*	coarse	6	655 648
138	24	*10*				fine muddy		
302	0.5–2		*50*		*300*	coarse		
303	2–5		*100*		*100*	fine		

TABLE 4. Longitudinal muscle formulae of *Phoronis psammophila* recorded in the Pacific Ocean and southern Australian waters (see Fig. 1 for locations). N = number of specimens examined.

Locality	N	Mean	General Formula	
13. New Zealand	6	$26 = \dfrac{9 \mid 9}{4 \mid 4}$	$\dfrac{9-10 \mid 8-9}{4-5 \mid 4-5}$	[25−28]
16. Spencer Gulf	8	$33 = \dfrac{11 \mid 10}{6 \mid 6}$	$\dfrac{10-14 \mid 9-12}{5-6 \mid 5-8}$	[29−39]
20. Panama	33	$37 = \dfrac{13 \mid 12}{6 \mid 6}$	$\dfrac{9-16 \mid 9-14}{5-9 \mid 5-9}$	[28−48]
9. Solomon	4	$37 = \dfrac{11 \mid 12}{7 \mid 7}$	$\dfrac{10-12 \mid 11-12}{7-8 \mid 6-9}$	[35−38]
5. China	10	$38 = \dfrac{11 \mid 12}{8 \mid 7}$	$\dfrac{9-14 \mid 10-14}{7-9 \mid 6-9}$	[33−46]
2. Russia	11	$39 = \dfrac{12 \mid 12}{8 \mid 7}$	$\dfrac{10-14 \mid 10-15}{6-10 \mid 6-9}$	[32−46]
11. New Caledonia	22	$40 = \dfrac{13 \mid 12}{8 \mid 7}$	$\dfrac{9-17 \mid 8-18}{5-11 \mid 5-10}$	[29−53]
15. Melbourne	36	$47 = \dfrac{15 \mid 15}{9 \mid 8}$	$\dfrac{11-19 \mid 11-17}{6-11 \mid 6-11}$	[34−53]
19. Hawaii	2	$\dfrac{10 \mid 10}{7 \mid 7} = 34$ and	$\dfrac{11 \mid 10}{6 \mid 6}$	$= 33$
Total for species	3 137	$35 = \dfrac{12 \mid 11}{6 \mid 6}$	$\dfrac{7-19 \mid 7-18}{4-11 \mid 4-11}$	[24−53]

Diagnosis

Embedded vertically in soft sediments, generally coarse sands. From 0 to 55 m depth.

Length in extension up to 150 mm, diameter 0.5-2 mm. Colour in life: body pink; lophophore transparent with pigment spots. Lophophore horseshoe-shaped with ends turned medially, up to one coil. Tentacles up to 160, length 2-3 mm. Nephridia with single funnel, descending and ascending branch, nephridiopore on anal papilla opening below anus on collar fold within invagination. Giant nerve fibre paired, left fibre only present below nephridial level on left side (15-35 μm in diameter). Longitudinal muscle bundles of feathery type; general formula is:

$[44\text{-}102]\ \dfrac{14\text{-}33 \mid 13\text{-}34}{7\text{-}20 \mid 6\text{-}20}$, mean formula is $68 = \dfrac{22 \mid 21}{13 \mid 12}$.

Sexual reproduction dioecious; females probably having brooding pattern; males with large glandular lophophoral organs. Asexual reproduction by transverse fission.

Larva: unknown.

Remarks

In South Australia, during the benthic survey of Spencer Gulf, *Phoronopsis albomaculata* was recorded at three stations, occurring with *Phoronis psammophila* at St.33 (Fig. 2; Table 2). Its density reached about 70 individuals.m^{-2} at St.27; a similar density (up to 75 individuals.m^{-2}) has been cited near Tuléar, Madagascar, by Thomassin & Emig (1983).

During a survey of the Nouméa lagoon (New Caledonia) (Fig. 3; Table 3), *Phoronopsis*

TABLE 5. Longitudinal muscle formulae of *Phoronis albomaculata* recorded in the Pacific Ocean and southern Australian waters (see Fig. 1 for locations). N = number of specimens examined.

Locality	N	Mean	General Formula	
20. Panama	22	$54 = \frac{18 \mid 18}{9 \mid 9}$	$\frac{16-21 \mid 15-23}{8-12 \mid 8-12}$	[47– 67]
14. Portobello	4	$56 = \frac{18 \mid 19}{10 \mid 9}$	$\frac{18-19 \mid 18-19}{8-13 \mid 8-10}$	[54– 59]
16. Spencer Gulf	34	$56 = \frac{19 \mid 18}{10 \mid 9}$	$\frac{15-22 \mid 13-21}{8-12 \mid 7-11}$	[44– 63]
15. Melbourne	14	$59 = \frac{19 \mid 20}{10 \mid 10}$	$\frac{14-23 \mid 15-24}{7-13 \mid 7-13}$	[46– 68]
11. New Caledonia	10	$65 = \frac{21 \mid 19}{13 \mid 12}$	$\frac{17-27 \mid 17-21}{10-15 \mid 9-13}$	[53– 76]
2. Russia	31	$67 = \frac{21 \mid 21}{13 \mid 12}$	$\frac{14-27 \mid 16-28}{9-17 \mid 6-17}$	[48– 80]
10. Moreton Bay	20	$80 = \frac{26 \mid 24}{16 \mid 14}$	$\frac{19-33 \mid 19-33}{12-20 \mid 12-16}$	[62–102]
Total for species	240	$68 = \frac{22 \mid 21}{13 \mid 12}$	$\frac{14-33 \mid 13-34}{7-20 \mid 6-20}$	[44–102]

albomaculata was collected by B. A. Thomassin at several stations characterized by coarse sand and fine sand at a low density of 3-9 individuals.m^{-2}.

In Otago (New Zealand) (Fig. 1), the species cited as *Phoronopsis* sp.1 by Rainer (1981: St.B10) has been identified by us as *Phoronopsis albomaculata* (material deposited in the Portobello Marine Laboratory): this species occurs at 4 m depth with a mean abundance of 9.7, in a sandy bottom (fraction 2-3 φ = 65.5%) with a large amount of coarse material and 14% organic detritus, under the influence of tidal currents. This record is from one of the coldest coastal locations in New Zealand, with water temperatures of 5-7°C in winter.

In the Russian Far East (Fig. 1) where the locations are under the influence of subtropical waters, *Phoronopsis albomaculata* has been recorded between 8 and 45 m depth with a density 8-20 individuals.m^{-2}, but up to 312 individuals.m^{-2} at 25 m in Poss'yet Bay (Emig & Golikov 1990).

As in *Phoronis psammophila*, no relationship could be established between geographical populations of *Phoronopsis albomaculata* on the basis of their muscle formulae (Table 5).

CONCLUSIONS

Phoronis psammophila is a cosmopolitan species and *Phoronopsis albomaculata*, previously considered as a tropical species, appears now as a tropical-temperate species according to its life conditions in New Zealand. The latter occurs in similar types of sandy bottoms to *Phoronis psammophila*, but in general in those with a higher amount of the coarse fraction under the influence of stronger near-bottom currents; *P. psammophila* has a higher density in well-sorted fine sands (Thomassin & Emig 1983). Such factors should explain the distribution of both species in Spencer Gulf and in the Nouméa lagoon and their co-occurrence in some locations.

The present data provide confirmation that, in Phoronida, low densities occur in tropical and subtropical waters (Emig 1982b; Thomassin & Emig 1983) in contrast to the higher densities which are cited at higher latitudes. For example, *P. psammophila*: 18000 individuals.m^{-2} in Marseille (South of France; Emig 1982b) and *Phoronopsis albomaculata*: 325 individuals per m^{-2} in the Poss'yet Bay (Russia Far East).

The taxonomic characters of *Phoronis australis*, *P. psammophila* and *Phoronopsis albomaculata* show strong similarities over the whole Pacific area, except for the muscle formulae, which vary widely within and between geographical locations.

Acknowledgments

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GARAWA METHODS OF GAME HUNTING, PREPARATION AND COOKING

MICHAEL PICKERING

Summary

This paper describes the traditional methods of hunting, fishing, preparation, and cooking of major food animals as practised by the western Garawa people of the inland Gulf of Carpentaria, Northern Australia. The data supports an hypothesis that similar strategies for game exploitation existed across differing Australian environments and may also be reflected within the archaeological record.

GARAWA METHODS OF GAME HUNTING, PREPARATION AND COOKING

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This paper describes the traditional methods of hunting, fishing, preparation, and cooking of major food animals as practised by the western Garawa people of the inland Gulf of Carpentaria, Northern Australia. The data supports an hypothesis that similar strategies for game exploitation existed across differing Australian environments and may also be reflected within the archaeological record.

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This paper is part of an exercise in salvage ethnography, the collection of data from a society which no longer practises the activities described. It is derived from information collected as part of an investigation into western Garawa traditional land use and site location patterns for the purpose of developing land use models applicable to archaeology.

The western Garawa represent a hunter-gatherer population adapted to the exploitation of a transitional sub-humid to semi-arid environment (Fig.1). Little information relevant to land use, site patterning, and related economic activities is available for such environments.

The aim has been to avoid the analytical manipulation of the data as far as possible, in favour of providing a usable ethnography. Garawa hunting strategies and preparation methods fall into three broad classes, depending primarily on animal size and general habitat. These are defined here as 'large game', 'small game' and 'aquatic game' strategies. Within each strategy there are both general and specialised methods.

Part of the author's research into Garawa land use and site patterning has involved the comparative analysis of changes in land use patterns between environmental zones. The Garawa information, as an example of economic use of a transitional environment, provides a link between the arid and tropical environments. Preliminary analysis of Garawa land use patterns and comparison with patterns from arid and humid environments suggests that highly predictable relationships exist between land use patterns and the environments in which they operate. Further, the progressive and gradual shift between environments appears to be accompanied by similar, and predictable, shifts in regional land use patterning. Results to date suggest that it may be possible to reconstruct regional patterns of prehistoric land use on the basis of environmental reconstruction and ethnographically derived models.

Garawa hunting and gathering practices reflect elements of both tropical humid to sub-humid and semi-arid to arid land use patterns. Without the mediating influence of the Garawa information the emphasis will always tend to be on the differences between these two environmental extremes. The Garawa land use data will allow for better comparative studies. Similarly the game hunting and preparation methods presented here demonstrate some degree of continuity between methods applied in both northern and southern environments (see Isaacs 1987).

The value of the Garawa data, therefore, lies in its application in comparative studies, where it not only demonstrates differences, but also similarities, between different environments. This allows for the better development of models of game processing relevant to the interpretation of the archaeological record.

METHODOLOGY

Information was collected through interviews with senior Garawa, supplemented by observation where possible. The reliance on interviews determines the 'salvage' nature of this ethnography. The practices described are rarely undertaken today.

The two major methodological problems associated with reconstruction of past practices through oral history rather than observation are those of informant reliability and information quality. The problem of informant reliability, where it is difficult to confirm whether an account accurately reflects common practice, is largely overcome through comparing consistencies in different accounts of the same practice. The methods presented here are those most consistently provided and agreed upon by informants.

The problem of information quality is that it is difficult to obtain more than a very generalised description of past practices. Where observation by researchers is possible, consistencies, anomalies and peculiarities are more easily defined and allow for a more detailed account (*e.g.* Meehan 1982, Baker 1988, Bradley 1991). Opportunities for such detailed

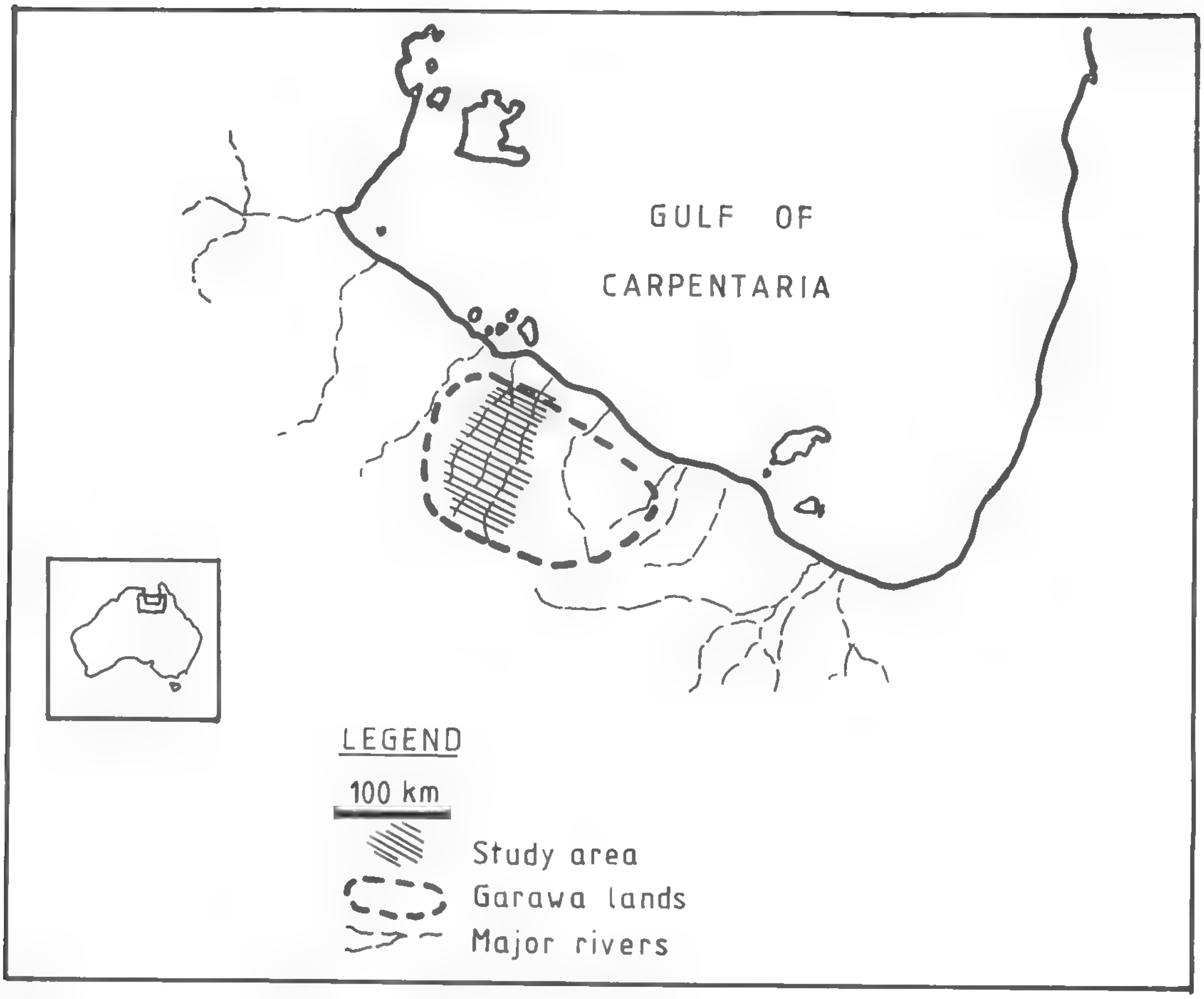

FIGURE 1. Location of Garawa country and study area.

observation are, however, decreasing. Where observation is not possible and where the account is considerably removed in time and space from the action, there is an inherent tendency towards generalisation. Generality in these ethnographic accounts should not be dismissed, when the only alternative may be no information at all. Moreover, a tendency towards generality can have its benefits, as Thomas has observed (1976: 73):

> Much of the so-called popular anthropology (the far-away-places-with-strange–sounding-names school) emphasizes the *range* of the human condition, often with a profound neglect of *central tendencies.*

The accounts provided here, although generalised, go some way towards contributing to the definition of some of these 'central tendencies'.

Animals are referred to in the text by their common names. This reflects the nature of the information, where exact identification of animals was usually not possible. Table 2 provides a summary listing of common and species names of major game animals.

Common names are preferred to species names in the text of this paper. Species names are often used indiscriminately by ethnographers, with the result that undue emphasis is placed on distinguishing specific animals rather than on the methods used to exploit them. The resulting inference is that a technique represents a specific response to a particular species, and may not also be found in different environments where that species may be absent. This paper suggests that in many cases the same methods can be applied to a variety of species of a particular genus from different environments.

The question of generating reliable analogies applicable over space and time is central to the 'land use' study from which this paper is derived. It is relatively rare for the considerable data on the economic, technological, and social practices of Australian hunter-gatherers to be used by researchers outside Australia, using ethno-archaeological models. This may be a result of the belief that distance lessens the reliability of an analogy, though researchers have often seen little difficulty in comparing ethnographic

and archaeological societies between the Old and the New Worlds (*e.g.* Binford 1983; Villa *et al.* 1986; Pickering 1989). The reluctance to include Australian material in comparative hunter-gatherer studies has also been aggravated by an over-emphasis on the unusual aspects of Australian flora and fauna. It may, for example, be argued that methods for hunting emu and kangaroo have little application to the interpretation of the archaeology of deer hunters of Europe or America. But if emus and kangaroos are approached in the context of 'large game grazing animals', rather than as 'flightless bird and leaping marsupial', the range of possible strategies for the hunting of 'large game grazing animals' is expanded. Similar concerns have been expressed by Clarke (1978: 109-110).

The Garawa And Their Environment

The Garawa

The Garawa occupy the transitional zone between the northern sub-humid to humid tropics and the southern central semi-arid to arid inland (Fig. 2). There is little information on hunter-gatherer land use or economics within this environmental zone, most studies focusing on arid desert and humid tropical environments.

Garawa social and religious phenomena are not discussed here. More specific information on these issues is provided by Avery & Mclaughlin (1977), the Aboriginal Land Commissioner (1985, 1990), and Trigger (1982, 1989). In summary, the Garawa largely conform to general principles of social and religious organization and land tenure common to northern Australian Aboriginal groups (see Maddock 1972).

Environment

Garawa homelands lie in the southern Gulf of Carpentaria between latitudes 20 degrees and 14 degrees south. The study area contains three major physiographic divisions: the northern Coastal Plains (30% of study area), characterised by lowland plains rising to undulating country; the central Gulf Fall (50% of study area), characterised by low hills and undulating country and the southern Bukalara/Barkly Plateau (20% of study area), characterised by escarpments, plateaux, and upland plains (after Aldrick & Wilson 1990).

Garawa occupation of the region centred on the major north-south running river and stream systems of the Gulf Fall, with seasonal excursions into the hills of the Bukalara/Barkly Plateau, and onto the plains of the Gulf Fall.

The heart of Garawa country lies on the notional division between the sub-humid and semi-arid climatic zones. Climate is characterised by dry warm winters (the dry) and hot wet summers (the wet). The wet summers are shorter than for the more northern humid and sub-humid climatic zones with a progressive decrease in rainfall from north to south.

The vegetative pattern of the region shows a decrease in the eucalypt-dominant tree canopy from woodland in the north to low open woodland in the south. The northern Coastal Plain consists of low to medium eucalypt woodland with intermittent low to medium melaleuca woodlands and tussock grass understorey. Foliage cover in the tree stratum is 10 to 30%. The Gulf Fall consists of low open eucalypt woodland with tussock grass and hummock grass understorey. Foliage cover in the tree stratum is usually less than 10%. The

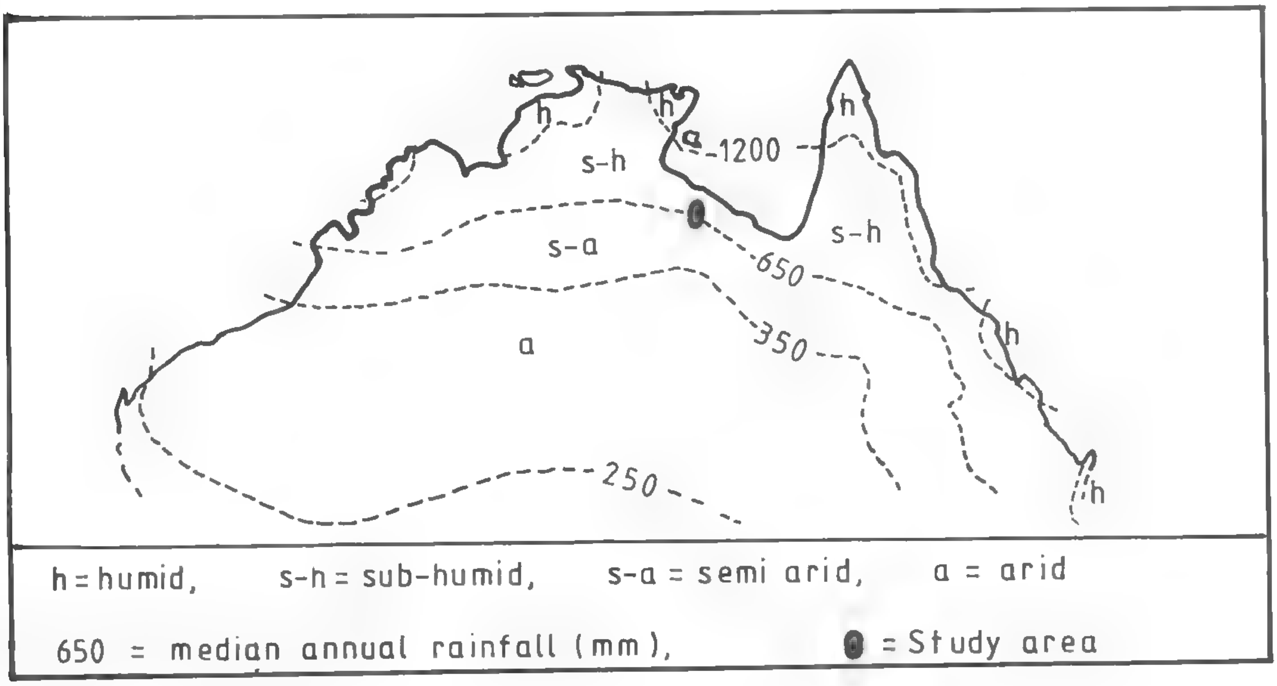

FIGURE 2. Climatic zones (after Gentilli 1986: 30).

Bukalara/Barkly Plateau consists of low eucalypt woodland with sparse tussock and herbaceous grasses. Foliage cover in the tree stratum is less than 10%. All three physiographic divisions are transected by major fluvial corridors which support localised corridors of diverse woodland and open woodland communities (after Nix & Kalma 1972; Australian Surveying and Land Information Group 1989; Gentilli 1986; Aldrick & Wilson 1990).

Land Use

Garawa land use followed the seasonal pattern. This saw an annual cycle of four major seasons: the storm time and rain time of the wet summer months and the cool time and hot time of the drier winter months. The late wet season saw a dispersal of the population from the major core areas along the river systems of the Gulf Fall into the adjacent plains and hills, now made accessible by temporary waters and seasonal efflorescence of resources. After the summer rains ceased, the progressive loss of peripheral temporary waters and resources saw a corresponding contraction of the population, through the semi-permanent waters of the major streams and lagoons, to the permanent waters of the rivers. By the late hot season the population was concentrated along the rivers where it remained through the hot, storm and early wet seasons.

This pattern of seasonal movement occurred over a relatively small area. The average range radius of the Garawa land-using group was 15 kilometres, usually centred on a major permanent water source. Late wet season camps, usually in the caves of the hills and plains, and cool season camps, usually on the semi-permanent waters of the river pools and lagoons, often fell within this 15 kilometre radius. People were rarely more than one day's walk from the richer 'core' territory of the major river channels.

This cycle of medium range movement reflected the seasonal distribution, abundance, and quality of food and water resources.

The Ground Oven

The ground oven was the most common method of cooking quantities of meat and vegetables. The author observed a number of ground ovens in use and given its role in Garawa food preparation, it is appropriate to describe its construction and operation.

The explorer Ludwig Leichhardt passed through the Gulf region in 1847 and noted:

> The fire places of the natives were here arranged in a straight line, and sheltered from the cold wind by dry branches: they were circular, the circumference was slightly raised, and the centre depressed and filled with pebbles, which the natives heat to cook their victuals.
> (Leichhardt 1847: 382)

The manufacture of a ground oven consisted of digging a pit large enough to accommodate the quantity of food to be cooked. The smallest ovens were little more than a shallow scrape in the sand — slightly less than a metre across and fifteen centimetres deep — and were used to cook several fish, fruit bat, or a lizard. The pits of larger ovens measured two metres across by 80 cms deep and could accommodate two or three kangaroos.

A large fire was lit in or adjacent to the pit. The animal was briefly thrown on it to singe off its fur, feathers or quills. The animal was quickly removed and the skin scraped and brushed clean. Larger animals were usually then gutted. When the fire had died down to hot coals, about two-thirds of these were placed in the pit. The carcass was laid in the coals and the remaining coals arranged on and around it. If stones were available these were heated in the fire and stuffed into the body cavity (in the case of larger game) or were placed around the animal.

The animal and its blanket of coals were then covered with sheets of paperbark or other vegetation to hand. This provided both a heat and steam seal and kept the meat clean. Soil was then packed over the paperbark. The oven was considered to be well sealed if no steam or smoke was seen to escape. The oven was then left alone for varying periods, from one hour for limited amounts of small game and fish, to overnight (eight hours) for larger game or greater bulk, though the latter time period often depended upon people's enthusiasm for opening the oven in the middle of the night. Three to four hours appears to have been the maximum cooking period for large game.

The oven and stones would be re-used if a site was continually occupied or re-occupied. Once game was cooked little artefactual assistance was necessary to butcher any animal. Cooked animals were easily dismembered and apportioned by hand, severing at joints and along muscle faces. Suitable long bones were occasionally cracked to extract the marrow. This produced long and irregular splinters. The consumption of marrow was not a regular occurrence and depended upon individual preference at the time.

Bone Burning

Bone and shell remains were commonly thrown into the fireplace and 'burnt'. The western Garawa informants describe this as mandatory and necessary to ensure a continued plentiful supply of fat animals. Robins & Trigger (1990: 45-48) describe slightly differing patterns of bone burning practice amongst the eastern Garawa and their Waanyi and Ganggalida neighbours.

The Garawa definition of 'burning bone' does not necessarily guarantee its destruction. Bones are 'burnt' by throwing them into the fireplace which was rarely hot enough to completely destroy or reduce the bone. Bones were often only slightly charred or calcined. Calcined bones easily broke into small fragments similar to those often associated, by archaeologists, with breaking of bones for marrow extraction.

Animals And Strategies

Game hunting and preparation methods are considered here to fall into three major strategy classes, defined primarily according to animal size and general habitat. 'Large game' strategies targeted the highly mobile animals found in the fluvial corridors and plains: kangaroos, wallabies, emus, and bush turkeys.

TABLE 1. Seasonal frequency of major food animals.

	WET				COOL			HOT		STORM		WET
	J	F	M	A	M	J	J	A	S	O	N	D
ANIMAL												
Mammals												
Macropods	OOO	OOO	OOO	OOO	OOO	OOO	OOO	OOO	OOO	OOO	OOO	OOO
Possum	ooo	...	...	...	...	...	...	...	...	...	.oo	ooo
Bandicoot	ooo	o..	...	...	...	...	...	...	...	...	...	.oo
Echidna	...	...	...	...	...	...	...	...	...	...	.oo	ooo
Dingo	...	...	...	...	...	...	...	...	...	...	...	...
Fruit bat										OOO	OOO	OO
Reptiles												
Goanna	OOO	OOo	ooo	ooo	ooo	ooo	ooo	ooo	ooo	ooo	oOO	OOO
Blue-tongued lizard	OOO	Ooo	ooo	ooo	ooo	ooo	ooo	ooo	ooo	ooo	ooo	OOO
Frilled lizard	ooo	ooo	o..	...	...	...	...	...	...	ooo	ooo	ooo
Black-headed python	...	...	.oo	ooo	ooo	ooo	oo.	...	...	...	...	...
Tortoise (longneck)	...	...	...	...	...	oOO	OOO	OOO	OOO	OOO	Ooo	...
Tortoise (shortneck)	...	...	...	...	...	...	...	oOO	OOO	OOO	OOo	...
Water snake	...	...	...	...	...	...	...	...	...	...	...	...
Crocodile	...	...	...	...	...	...	...	...	...	...	...	...
Birds												
Emu	OOO	OOO	Ooo	ooo	ooo	ooo	ooo	ooo	ooo	ooo	ooO	OOO
Plains bustard	...	...	...	...	...	...	...	...	...	...	...	...
Bird eggs		..	...									
Birds (spp.)*							...	...	...			
Fish												
Fish (all spp.)	...	...	...	...	...	...	.oo	ooO	OOO	OOO	Ooo	...
Freshwater crayfish	...	...	...	...	...	...	ooo	ooo	ooo	oo.	...	...
Freshwater mussel	...	...	...	...	...	...	ooo	ooo	ooo	o..	...	...
Insects												
Sugarbag	ooo	ooo	ooo	ooo	ooo	ooo	ooo	OOO	OOO	OOO	OOO	ooo
	J	F	M	A	M	J	J	A	S	O	N	D
	WET			COOL				HOT		STORM		WET

..... = Low frequency
ooooo = Medium frequency
OOOOO = High frequency
* = north of study area

'Small game' strategies targeted the localised animals of the lagoons, plains and hills: snake-necked tortoises, lizards, possum, echidna, fruit bats, crocodile, etc. 'Aquatic game' strategies targeted animals of the semi-permanent to permanent waters: fish, short-necked tortoises, crayfish, crocodiles, and mussels. Table 1 provides a summary of the seasonal distribution and relative abundance of animal resources referred to in this paper.

Classification on the basis of size does not reflect the overall contribution which each class of game made to Garawa diet. A large game hunt could proceed in the full knowledge that an alternative, more productive, and more accessible small game meat source was available. A successful large game hunt might also produce less meat than a moderately successful small game hunt or fishing trip.

While most native animals are edible not all were consumed. This was a result of numerous factors, including flavour, ease and economy of capture and general palatability, the latter being more a subjective, rather than a nutritional, determinant. The decision as to target was based not only upon the availability of the resources and the economic efficiency of pursuing it, but also upon the hunter's sex, personal preference, enjoyment and ego. The result is that a simple listing of potential food species, as is common in reconstructions based largely on reference to basic floral and faunal data, would not accurately reflect the list of actual food species which dominated the diet.

Table 2 provides a summary listing of the major species utilised. This table is compiled on the basis of informants' descriptions of animals rather than on carcass identification. It is considered a minimum listing of actual food species and no doubt a number of other species were also utilised. A large number of potential food species is available in Arnol *et al.* (1983) which lists animal species for the western neighbouring McArthur River Catchment.

Large Game Strategies

The general strategy

There was a general strategy applied to all large game animals. This was the simple stalking of game sighted while hunting opportunistically. Prior to a stalking hunt the hunter would smear himself with white ochre. This concealed the smell of the hunter and provided a degree of camouflage through breaking up the hunter's outline. Occasionally the camouflage would be supplemented by holding two small leafy branches (70–100 cms) butt to butt, effectively forming an 'hourglass' of leaves which assisted in concealing the hunter. The hunter would then carefully stalk to within effective spear range of the target, usually within 10 metres. This method was most commonly used with large game animals encountered unpredictably in the open woodland country of the plains and low hills.

The aim in large game hunting was to disable the animal to the point where capture was assured. Immediate death or disabling injury were equally acceptable. The largest, and preferred, target zone of most large game was the hips, pelvis, and lower abdomen. The result was that in a successful hunt animals were often wounded to the point of being unable to escape. In this incapacitated state the animal might be left alive until required. This was rarely longer than a few hours but might extend overnight. In a warm to hot climate this considerably prolonged the freshness of the meat.

The hunting of large game animals was usually the preserve of males although the capture of a wounded animal could involve women and children. Until rifles became commonly used, the hunting tool kit comprised spears with wood, stone, or metal heads, spear throwers, and a stone or steel knife.

Hunters would go out singly or in company. They rarely stayed out from the base camp longer than one day, although occasionally one to three night hunting camps would be made. The hunter's family might accompany him on overnight trips, remaining at a small hunting camp while he ranged further afield during the day.

Dingoes, and later domestic dogs, which had proven useful hunters, would be used occasionally, particularly in pursuing wounded game. The dogs would quietly remain with the hunters' extra spears and equipment, which was put down when a target was sighted. When the prey was hit the hunter would call up the dogs which would scent the blood and pursue and harass the animal until the hunter could catch up.

Upon the capture of a large animal a fire would be lit to signal other hunters in the vicinity and residents of the home camp. If the hunter was some distance from the home camp the animal might be partially prepared by gutting, singeing of fur or feathers, and occasionally by complete cooking on site. If the members of the home camp were particularly hungry they would go out to meet the hunter.

Macropods

There is a variety of macropod species in all the environmental zones of the study area. These range in size from the large heavy common and antilopine wallaroos and the occasional red kangaroo through to the smaller agile wallabies (see Table 2).

By all accounts macropods were caught regularly, with reports of at least one per hunter per week being a minimum and with one to two per day being the regular capture rate for a good hunter.

The best time to hunt macropods was in the early morning or late evening when they were feeding and watering in the open, close to main water sources. During the hotter midday period they would disperse to shelter under trees and in rock shelters which effectively concealed them from hunters and allowed

them to be warned of a hunter's approach. The cool season, between March and August, was the optimum time for hunting macropods, though they were available and were hunted all year long. The wet season abundance of food and water encouraged game to disperse widely onto the plains and into the hills. By August, as the hot season commenced, the animals were forced, by dwindling food and water, to retreat to the more permanent waters where the Garawa were also focused. This concentration of numbers meant that their availability and behaviour became more predictable at this time. Apart from this general strategy of careful stalking of opportunistically sighted game, there were several other specialised techniques. One technique, used when a resting hill kangaroo (wallaroo/euro) was sighted lying in a low rock shelter, was to quietly move to a point immediately above the shelter. The hunter would then wipe a stone under his

TABLE 2. Major game animals.

Common Name	Species	Weight/Size	Reference
Mammals			
Northern nailtail wallaby	*Onychogalea unguifera*	4.5-9.0 kg	Gordon 1983a: 204
Agile wallaby	*Macropus agilus*	9.0-27.0 kg	Merchant 1983: 242
Common wallaroo/euro	*Macropus robustus*	6.25-46.5 kg	Poole 1983: 251
Antilopine wallaroo	*Macropus antilopinus*	16.0-49.0 kg	Calaby 1983a: 253
Red kangaroo	*Macropus rufus*	17.0-85.0 kg	Sharman 1983: 255
Rock ring-tail possum	*Pseudocheirus dahlii*	1.28-2.0 kg	Nelson & Kerle 1983: 132
Northern brush-tail possum	*Trichosurus arnhemensis*	1.1-2.0 kg	Kerle 1983: 149
Northern quoll	*Dasyurus hallucatus*	300-900 gm	Begg 1983: 23
Black-footed tree rat	*Mesembromys gouldii*	430-870 gm	Calaby 1983b: 383
Northern brown bandicoot	*Isoodon macrous*	0.5-3.1 kg	Gordon 1983b: 96
Echidna	*Tachyglossus aculeatus*	2.0-7.0 kg	Augee 1983: 8
Dingo	*Canis familiaris*	9.6-19.4 kg	Newsome 1983: 483
Black flying flox	*Pteropus alecto*	500-700 gm	Hall 1983: 280
Little red flying fox	*Pteropus scapulatus*	300-600 gm	Richards 1983: 277
Reptiles			
Freshwater crocodile	*Crocodylus johnstonii*	2.0 m	Cogger 1980: 2
Snake-necked tortoise	*Chelodina rugosa*	30 cm	Frith 1983: 22
Northern snapping tortoise	*Elseya dentata*	30 cm	Frith 1983: 23
Short-necked tortoise	*Elseya australis*	30 cm	Cogger 1980: 6
Gould's goanna	*Varanus gouldii*	7.0 kg	Frith 1983: 34
Mertens' water monitor	*Varanus mertensi*	1.0 m	Frith 1983: 45
Spotted tree monitor	*Varanus timorensis*	60 cm	Frith 1983: 37
Blue-tongued lizard	*Tiliqua scincoides*	30 cm	Frith 1983: 45
Frilled lizard	*Chlamydosaurus kingii*	85 cm	Frith 1983: 31
Black-headed python	*Aspidites melanocephalus*	3.0 m	Frith 1983: 47
Arafura file snake	*Acrochordus arafurae*	2.5 m	Frith 1983: 50
Little file snake	*Acrochordus granulatus*	1.0 m	Frith 1983: 50
Birds			
Emu	*Dromaius novaehollandiae*	1.5-1.8 m	Pizzey 1982: 21
Plains bustard	*Ardeotis australis*	15.0 kg	Pizzey 1982: 107
Fish			
Black bream	*Hephaestus fuliginosus*	30 cm	Arnol *et al.* 1983: 302
Salmon catfish	*Hexanematichthys* sp.	30 cm	Arnot *et al.* 1983: 302
Eel-tailed catfish	*Neosilurus* sp.	30 cm	Arnot *et al.* 1983: 302
Sleepy cod	*Oxyeleotris lineolatus*	20 cm	Arnol *et al.* 1983: 302
Barramundi	*Lates calcarifer*	50 cm	Arnol *et al.* 1983: 302
Perch	*Abassis* spp.	20 cm	Arnol *et al.* 1983: 302
Archer fish	*Toxotes charareus*	15 cm	Arnol *et al.* 1983: 302
Freshwater crayfish	*Cherax quadricarinatus*		Arnol *et al.* 1983: 303
Freshwater mussel	*Velesunio angasi*	8 cm	Arnol *et al.* 1983: 303
Insects			
Sugarbag/Native bee	*Trigona plebia* *Trigona tetragona*		Akerman 1979: 169 & Michener 1965: 230-1

(0.0 cm) = average size based on observations.

armpit, wetting it with sweat and then throw the stone upwind of the animal. The noise and scent would alert the animal which would try to escape downwind. Once out of concealment the animals often pause briefly to check the source of alarm. This usually occurred within effective spear range (within 10 metres).

Another technique, used in the wet season around the replenished swamps and lagoons of the plains, was for hunters and dogs to drive the macropods into boggy or swampy ground where they could be clubbed. They could also be driven towards hunters. This appears to have been an opportunistic rather than a premeditated strategy. A group on a hunting or foraging round might sight macropods but be in a poor position for pursuit (*e.g.* upwind, no spears, etc). The group might attempt to drive the animals in the direction of known hunting parties. Occasionally fires would be lit to assist the drive.

Once killed the macropod was prepared for cooking. The fur was singed, scraped off, and the animal gutted, with the exception of the heart and lungs which did not contaminate or flavour the meat. The stomach and part of the intestine were cleaned and then stuffed with the intestinal fat. This package was placed inside the body cavity. The front legs would be tied together with bark. The hind legs would be snapped forward at the joint of the femur and tibia. This allowed the legs to be laid flat along the body. The tail would be partially severed at the base to allow it to be bent along the body. The tail and hind legs would then be secured by passing them through the tied forelegs. The animal was then cooked in a ground oven.

Emu

As well as the stalking strategy described there were several specialised strategies for hunting emu. These relied for their success on the predictability of the birds' behaviour. The best time for emu, the period when their presence and behaviour was most predictable and when they would be in the best condition, was in the late wet season (February – March) and early cool season (March – April). This was the time when the trees fruited along the temporary seasonal watercourses, providing the emus' favourite food.

An extension of the general strategy involved waiting in concealed hides at water sources where fresh tracks had been observed, spearing the emu upon its return to water.

During the wet season the most common method, in the course of general foraging, was to look for fresh tracks at the base of fruit trees. The hunters would return to these trees the next morning and would make a simple platform, or 'nest', in the branches, ensuring that there was sufficient room to use the spear and spear-thrower. When the emu returned to eat the freshly fallen fruits the hunter would spear it.

The curiosity of the emu was also exploited. Having sighted an emu the hunter would conceal himself and wave a cloth or object, occasionally making an unusual sound. The emu would approach the lure to within spear range. Often two men would co-operate, one providing the lure and the other standing ready with the spear. A further modification of this technique had the hunter lying down in the grass and waving a foot in the air. Again the emu would be attracted to within effective spear range.

Upon capture the emu would be plucked and the remaining feathers singed off. It was then gutted. The intestinal fat would be stuffed into the cleaned crop which would then be placed in the body cavity prior to cooking. The animal would then be cooked in a ground oven.

Emu eggs were eaten when found. Due to their strong, heavy shells they could be simply roasted in an earth oven without breaking.

Certain restrictions on the consumption of emu fat applied to women and children.

Australian plains bustard/bush turkey

The Australian bustards, or bush turkeys, were encountered opportunistically on hunting trips in the open woodlands. They were available throughout the year, though encounters were more likely in the wet season when they fed on the fruiting trees along the temporary watercourses. Bustards were a favoured food but rarely caught, largely due to the haphazard nature in which they were encountered combined with their alertness in avoiding hunters.

Once a bustard was sighted the general strategy of careful stalking was most commonly used. The bustards also returned to the same waters each day. A hunter, having observed fresh tracks near a water source, would lie in wait for the bustard's return, or would try there again in the early morning or late afternoon.

A captured bustard would be plucked, singed, gutted, and cooked in a ground oven.

Summary

Large game, relatively common throughout the year, was most frequently captured using a general stalking strategy. This was employed as the exact location of large game was unpredictable, with occasional exceptions. Under certain environmentally determined circumstances, where the likelihood of game encounter was increased, alternative and more specialised techniques could be applied. Animals were prepared and cooked in a standard way. Major carcass dismemberment usually occurred after cooking and was easily accomplished with little technological assistance.

Small Game Strategies

Small game strategies targeted a range of mainly terrestrial fauna. These animals provided the bulk of the Garawa daily meat diet. Small game animals were

usually highly predictable in terms of their location, seasonal availability, meat quality, and likely minimum capture numbers.

Although many of the small game species described here could be specifically targeted, most were captured opportunistically, in the course of general foraging. A simple example would see a hunter returning with a mixed bag of lizards, tortoises and 'sugarbag' honey.

Small game could be collected or hunted by males and females working singly or in company. A hunter after large game would nonetheless usually pursue any suitable small game he happened across.

Lizards and snakes

Lizards were a major food source with three main genera exploited, the monitor goannas, the blue-tongued lizards, and the frilled (or blanket) lizard.

The usual preliminary to lizard hunting was the burning-off of grass and leaf litter. The reason consistently given for burning grass was that it cleared the ground to facilitate the hunting of lizards. Fires were lit at any time of the year when the grass and litter looked flammable. Patches of less than a hectare were quite acceptable for this purpose. Hunters or foraging parties would regularly light such fires on their travels. A day or two later they would return to the burnt area to hunt for lizards. The burning-off produces a layer of black ash in which the tracks and burrows of lizards are easily seen.

When hunting lizards, Garawa would intensively work a localised area. In one observed episode three people took one hour to cover a 300 by 200 metre area for a return of two goanna and one blue-tongued lizard. The area was known to have been heavily exploited by another group not long before this hunt.

Goanna

Goanna were hunted throughout the year though they were more common, and in better condition, in the wet season and early cool season. During the heat of the day they occupy shallow burrows, easily located on a cleared ground surface through the freshness and bright colour of the soil from the burrow overlying the black ash and by the direction of the clear tracks. Once located the burrow was checked for an exit hole. If only one hole was present it was likely that the goanna was still inside. If there was an exit hole the burrow was considered unlikely to contain a goanna but was checked for other lizards and snakes. Checking consisted of probing the soil around the burrow with a digging stick or suitable implement. When a goanna was felt the hunter would dig along the length of the burrow to the lizard's tail, which was then seized and the lizard dragged out of the hole.

When a goanna was caught it could either be killed immediately by clubbing or alternatively, and more frequently, some or all of the legs were broken to disable the animal while keeping it alive. This 'breaking' consisted of bending the joint of the legs at the junction of the femur and tibia. This is variously described as breaking the leg, breaking the 'string', and 'hobbling'. With the legs immobilized the goanna could be kept alive and fresh until required. This could be for up to a month, when collecting prior to hosting ceremonies, although several days appeared to be the maximum. In this state the goanna could be given or traded to other people or kept in reserve for gatherings.

Once killed the goanna was gutted, usually through a cut at the junction of the neck and chest. Several goanna would be cooked in a suitably-sized ground oven, but a single goanna would be cooked in the open coals of the hearth. The legs were tied to prevent their spreading in the fire, and the animal was usually cooked belly down.

Water goanna were also hunted, though not with the frequency or success of the land goannas. These were usually caught using a single pointed spear while fishing.

Blue-tongued lizards

Blue-tongued lizards occupy the vacated burrows of goannas and were caught in the same way. One informant described them as " . . . bludger along goanna camp . . . ". They were available all year. When captured the blue-tongue could either be killed immediately or kept alive until required. Their legs were rarely broken to restrain them as they were considered fairly harmless. Once killed they were prepared and cooked in the same way as goanna.

Frilled lizard

The frilled (or blanket) lizard was mainly found around trees and logs. It was relatively scarce during the cool and hot seasons, becoming increasingly common during the storm and wet seasons. They were often seen in considerable numbers in front of grass fires where they were driven by flames and smoke. They were caught by clubbing or with dogs. The frilled lizard was considered a 'cheeky' lizard, likely to bite and scratch, and when caught they were immediately killed. They were prepared and cooked in the same way as goanna and blue-tongued lizards.

Snakes

Snakes were available throughout the year although the best season for hunting was the cool time when they were fat and slow. The most popular food species were the non-venomous varieties, particularly the black-headed python. Snakes were often captured while people hunted goanna, as they occupied disused burrows. Water snakes were occasionally caught while fishing or collecting lily roots. Once killed the snake would be coiled into a bundle and tied with bark. It was then cooked in a ground oven. The guts were removed after cooking.

Echidna and possum

Garawa use of the name possum appears to refer not only to the rock ring-tail possum and the northern brush-tail possum but also to other marsupials of similar size occupying similar environmental niches, such as the northern quoll and black-footed tree rat. This discussion refers to the possum but these other species were captured by the same methods.

Although unrelated species, the echidna and possum were caught using the same strategies and at the same time. The echidna, or spiny-anteater, and the possum are found throughout the region but are most abundant in the rocky low hills of the southern half of the study area. This habitat was usually not intensively occupied by the Garawa until the middle and late wet season and early cool season. In the early cool season the Garawa would move down to the flatter fluvial corridors and adjacent plains where echidna and possum were present but more dispersed and in fewer numbers and, by the advent of the hot season, in poorer condition. Hunters on the plains also targeted a different and relatively more locally abundant range of animals such as tortoise and lizards. Thus possum and echidna, although available all year, were only major food animals in the wet and early cool seasons when specialised methods were applied to their capture. In the cool and hot seasons these animals became a less frequent, more opportunistically exploited, part of the diet.

Echidna were hunted by both day and night. During the hot daylight hours they tend to rest in crevices and ant beds, becoming more active at night. In the daytime hunters would be alert for tracks, following these to the resting animal. Once located the animal was killed, either by clubbing the head or, when well dug in, by stabbing a small hardwood stick of about 40 cms in length, between the spines, under the ribs and into the heart.

Night hunting was used for both echidna and possum and largely relied on the use of suitably trained dogs. Hunters would go to the rocky hills on moonlit nights with proven hunting dogs. These would be allowed to run free. When the dogs located prey they would make a noise. The hunter knew this indicated they had caught or bailed up some animal and would go to check and kill the capture. The echidna was clubbed or stabbed, as described. Possum were usually forced into a tree or rock crevice by the pursuing dogs. The hunter would knock them down onto the ground with a club or spear where they could be clubbed, speared, or mauled by the dogs.

Echidna were prepared by first singeing the spines in an open fire. This loosened the quills and removed the sharp tips. The quills were then 'plucked', usually by laying the animal on a hard surface and 'pinching' out clumps of spines with a stone or back of an axe. Once plucked it was gutted. The tongue was tied into a knot. The common reasons given for this practice were that: 'it stopped the good fat dripping out', 'kept the devil from getting the fat', and " . . . because it's the law . . . ". The prepared echidna was cooked in a ground oven.

Possum would be prepared by first plucking the fur, which was kept for making fur belts, and then by gutting and cooking in a ground oven.

Fruit bats

Fruit bats were only available for the short period of the storm time and early wet season. They arrive in great numbers in late October and occupy the flowering fruit trees along the permanent river pools, departing quickly when flowering is finished and the heavy rains begin in late December. For this short period they made up a large proportion of the daily meat diet.

The method for hunting fruit bats was simple and effective. Hunters would have a special hardwood club of about a metre in length. Keeping the wind in their faces, so as not to alert the bat colony resting in the branches of the trees, they would rush in vigorously swinging the clubs, knocking the bats to the ground. Once hit the bat was usually disabled by a broken or damaged limb. It was then unable to escape and was left where it fell while the hunters continued striking.

A hunter would sometimes carry two or three smaller hardwood clubs, up to 50 cms long, which were thrown into the bats on the higher branches.

The disabled fruit bats would be collected and killed, being threaded onto the clubs by the wings for transport back to the camp. The fur was singed off in the open fire and the wings broken off at the 'elbow'. If a large number of bats had been caught they would be cooked in a ground oven. If only a few had been caught they would be cooked in the coals of an open fire. The bats would be gutted after cooking. The reasons for not gutting them prior to cooking were that they would lose too much good fat and that they were too small to worry about.

Cooked fruit bats would sometimes be wrapped in a paperbark bundle for transporting. In some special locations certain restrictions on consumption of fruit bats were applied to women and children.

Snake-necked tortoises

The snake-necked tortoise is found in the billabongs, lagoons, and swamps of the plains in the northern half of the region. These waters are characteristically temporary, relying on wet season replenishment by river flooding. Through the wet season to middle cool season these sources were full and the tortoises active and difficult to catch, although they were occasionally caught while netting for fish, by feeling for submerged holes in banks, or by jumping on them as they swam past. As the waters dried up in the late cool and hot seasons the snake-necked tortoise aestivated in the drying muddy pool beds. The exposed dry beds would

be examined for tell-tale lumps and cracks which indicated a buried tortoise. The tortoise was then dug out with digging sticks or a convenient unmodified stick. Tortoises considered too small for eating were returned to the hole and covered.

Captured tortoises would occasionally be kept alive until required. This could be for several hours to a few weeks. They were kept in steep sided pits. Today they are often kept in water-filled drums.

The tortoise was killed by clubbing, breaking the neck by bending or, more commonly in recent times, by cutting its throat. It was then thrown onto an open fire for a preliminary 'cooking', removed and the lower plate broken off, either by hand or with an axe. The guts were removed. The tortoise was then replaced on the coals belly-up, with the belly plate restored and held in place by a heated rock, if available. The belly-up position ensured the retention of fluids which made a popular 'gravy'. The prepared tortoises would be cooked on the open coals or, if a large number was caught, in a ground oven.

Tortoise eggs are available in the middle to late cool season between July and August. They were cooked in a ground oven by being sandwiched between two thick layers of grass.

Freshwater crocodile

Freshwater crocodile were available all year in the permanent pools of the rivers and billabongs. They formed an occasional supplement to the meat diet. Crocodiles were caught mainly by spearing, and occasionally while netting for fish, or by hand. Crocodiles were also sometimes affected by fishing poisons.

When caught by hand, as when feeling in submerged holes in the banks for fish and tortoise or when feeling pool bottoms for waterlily roots, the hunter, feeling a crocodile, would slowly run their hand up the body to the jaws. The jaws would be held shut, the tail grabbed and the crocodile dragged onto the bank where its jaws would be tied. The legs would also be tied if it was intended to keep the crocodile alive, otherwise it would be killed immediately by an axe or club blow to the back of the head.

Small crocodiles would be cooked whole after gutting. Larger crocodiles — more than 100 cms in length — would be butchered and cooked. Cuts would be made along the spine and the crocodile spread out. The tail was cut off and the body quartered. The flesh was then cooked in a ground oven.

Crocodile eggs became available around August. The eggs would be found in sandy banks along the watercourses, the hunter often following the recent track of the mother. Eggs were cooked in a ground oven in the same manner as tortoise eggs.

Sugarbag

'Sugarbag' is the colloquial name given to the hive of stingless insect species collectively known as 'native bee'. The name 'sugarbag' includes the honey, pollen, wax and residues of the hive. Sugarbag is included in the category of small game as it was both a regular and important animal-derived food and was one of the targets in the small game hunting and foraging strategy.

Sugarbag was exploited throughout the year, and was usually a part of the daily diet. In terms of quality and quantity it is at its best when the major trees flower around the end of the hot season, through to the early wet season.

Sugarbag is found in trees, termite mounds, and in crevices in rock formations. The best quality sugarbag was found in the trunks and branches of trees in well-watered country where flowering trees were more abundant. It was located by watching out for the small fly-like bees and the tubular entrance to the hive. When the hive was in trees the hunter would knock the trunk or branch in order to locate the position of the hive. They would then cut a small hole below the hive. If possible this hole would be large enough to insert a hand and extract the hive largely intact. Alternatively, when a hand could not be inserted, a stick, usually around 50 cms long and with one end frayed by pounding, would be inserted into the hole and up into the hive. The honey would flow down the stick into a bark container. The solid remainder of the hive would then be removed by prodding with the stick. If possible, wood chips and some wax would be used to patch the hole to give the hive some chance of re-establishing.

The main reason given for the cutting of a small hole was that it was too hard to make a larger hole with a stone axe. With the advent of steel axes it is now easier to cut directly to the hive.

Sugarbag in termite mounds and rock formations was called 'ground sugarbag'. Wherever possible it was excavated and extracted in a complete package so as to prevent soil contamination. In all cases a hive could produce up to a litre of honey, wax, and pollen. This was eaten with no further preparation. The wax would be chewed and kept for later use in hafting. Occasionally, and especially with badly mixed hive contents, the residues would be mixed with water to dissolve the honey and the mixture was drunk by straining through a bundle of dry grass. There are some reports that the wax was used as a depilatory by ancestors, an act which Garawa men recount with awe.

Sugarbag is classed by the Garawa into two forms: 'boy' sugarbag and 'girl' sugarbag. 'Boy' sugarbag is usually found in tree branches and is identified by its long waxy hive entrance and its greater honey yield. The 'girl' sugarbag, found in tree trunks and ground sources, has a shorter, wider hive entrance and contains more pollen than honey.

Miscellaneous Species

Numerous other species of small mammals, reptiles, and birds were exploited opportunistically. These served to supplement the major meat sources and did

not form a regular or reliable part of the diet. Animals in this group include dingoes, bird species, smaller wallabies and bandicoots. While a variety of animals could be hunted, only a small proportion were regularly exploited in quantities and frequencies sufficient for them to be considered animal staples.

Summary

Small game species could be either specifically targeted or exploited opportunistically, in both cases with some guarantee of a return. At certain times of the year particular species were more abundant and special effort, in the form of targeting and specialised techniques, was applied to exploit this abundance.

While capture of large game provided a greater quantity of meat in a single event, small game contributed more to satisfying the daily meat demand and provided diversity in diet.

Aquatic Game

This section describes the methods for the collection of several major fish species, including barramundi, black bream, catfish, rifle fish and 'cod', the two species of short-necked tortoises, freshwater crayfish, and mussels. These species are defined as 'aquatic' due to their reliance upon permanent waters. Methods used were often indiscriminate in terms of a precise target and could be used to capture a variety of species.

To some extent the exploitation of aquatic game continued throughout the year. In the months between December and August, when the water levels are reasonably high, aquatic animals provided a minor supplement to a meat diet targeting terrestrial fauna. It was only during the hot dry months of August to late November that aquatic game became a major part of the diet. This marked seasonality was due to two main environmentally determined factors. Firstly, the majority of the Garawa population would shift from permanent waters during the wet and cool seasons to exploit the seasonally abundant terrestrial game. Secondly, the techniques and technology used in the exploitation of aquatic game were inefficient when there was abundant or flowing water.

The most common techniques were general foraging, netting, log traps and weirs, and 'poisons'. General foraging was practised all year while the other specialised techniques were restricted to the drier hot season when water levels dropped rapidly to form small, still pools.

General foraging

This involved the opportunistic capture of aquatic animals and the collection of shellfish. Hunters would occasionally spear animals which swam within range. Tortoise would be captured by jumping on them as they swam past. People looking for waterlily roots or feeling submerged holes in banks would catch fish, tortoises, water snakes, and small crocodiles.

Mussels were easily collected throughout the year by simply feeling in the mud and sands in the shallow pool edges. Small numbers of mussels would be cooked in the coals of an open fire while large quantities would be cooked in a suitably sized ground oven. After cooking the meat would be removed from the shells and put in a paperbark container for transport back to the main camp. The shells would be piled back into the fireplace for 'burning', as described above.

Netting

The explorer Augustus Gregory passed through the region in 1856 and reported ' . . . a fishing-net made neatly of twisted bark, the mesh one and a half inch, the length perhaps thirty feet . . . ' (Gregory 1884: 13).

All aquatic game could be caught using nets. These were manufactured from bark and suitable grasses and were up to 10 metres long. Smaller nets of up to a metre in length were occasionally used as scoop nets. The larger nets had poles at each end with one in the middle to serve as a 'spreader'. The hunters would drag the net through the water, usually up to chest deep, and drive, manoeuvre, and surround the catch in the shallows where it could be caught by hand, clubbed, or speared. The nets were relatively fragile and could not contain a weight of game out of the water. Netting was used as pools became smaller and shallower in the hotter weather. The operation usually involved a minimum of three people.

Trigger (1987: 78-79) has reported similar accounts of net use from the eastern Garawa and Ganggalida people.

Log traps and weirs

In the middle and southern parts of the study region, above the range of tidal influences on the rivers, hollow logs were used as simple fish traps. These were used to catch catfish, cod, black bream, and freshwater crayfish. A suitably sized hollow log would have one end blocked with a wad of grass. It would then be placed in the water overnight, close to the bank. The next day the mouth of the log would be blocked and the log removed onto the bank. The end was then unblocked and the contents emptied out. A number of these traps could be in operation at any one time, spread around one or more waterholes.

In the northern part of the study area, on the flatter coastal plains, the inland river levels were somewhat affected by tidal movement. Here small weirs of branches would be placed across shallow channels to hold fish when the water level dropped. Leichhardt reported similar weirs in his 1845 expedition (Leichhardt 1847: 396, 402).

'Poisons'

Poisoning was the most frequently used fishing technique, though its application was restricted to the

hot season and to the smaller pools (less than 15 metres across). The branches and bark of several local tree species (*e.g. Barringtonia* spp., *Acacia* spp., *Eucalyptus* spp.) were suitable for poisoning the water. These would be broken up and dropped into the pools. The sap would make the water 'soapy' and the fish would rise stupefied to the surface where they could be speared, clubbed, scoop netted, or collected by hand.

Some poisons would also affect small crocodiles and tortoises by irritating eye, nose and mouth membranes and forcing the animals to the surface where they were captured.

Poisons took some time to degrade and disperse. Once a pool had been poisoned it was considered unsuitable for drinking water until flushed by the coming rains. The Garawa would therefore take care to maintain an unpoisoned body of water.

Trigger (1987: 78) has also briefly reported on the similar use of poisons by groups to the east of the study area.

Another technique which can be considered 'poisoning', as it affects the water quality, was the dragging of branches through the water to stir up the mud. This also forced fish and other animals to the surface where they could be caught.

Summary

Methods of capture were applicable to a variety of aquatic fauna. Specific aquatic game species were rarely individually targeted. Although it was always available, aquatic game became a major part of the meat diet in the hot months prior to the summer rains. Increased availabilty of aquatic game, due to its concentration caused by falling water levels, coincided with a drop in the number and condition of terrestrial fauna and a hot season congregation of the Garawa population around the permanent waterholes.

Discussion

The principal aim of this paper has been to provide basic ethnographic accounts of Garawa game hunting and preparation methods. The three summary classes described incorporate several methods, both general and specialised. These strategies more accurately match broad categories of animal size and habitat than specific species.

It is likely that the methods described here were those most commonly used in the day-to-day quest for game by the Garawa. The descriptions of the correct ways of catching and preparing game are consistent within and between informants' accounts. Indeed, where direct observation was possible, this showed a strong adherence to the verbal descriptions. Where exceptions did occur it was made clear that this deviation was anomalous and the result of certain, usually 'non-traditional' influences (for example, a decision to break camp prematurely to be in time to meet a mail plane).

The strategies provided here represent Garawa models of correct subsistence behaviour as much as they reflect real behaviour. Though special circumstances would produce deviations from these models these were usually short term. Through these generalised accounts the Garawa tacitly acknowledge that adherence to models of proven basic subsistence methods was as crucial to the physical well-being of the Garawa community as adherence to social laws was crucial to their psychological and spiritual well-being.

It may be argued that the data presented here adds little to the data on Aboriginal hunting methods known from studies elsewhere in northern Australia. The significance of the Garawa data, though, lies not only in its differences but also in its similarities to these other regional studies.

The existence of similar strategies of hunting and food preparation in conjunction with different land use patterns in different environments supports the hypothesis that optimum yet simple strategies existed for the exploitation of Australian game animals. Further, these strategies were adapted more to animal size than to specific species. This allowed them to be applied equally effectively in different environments.

As noted earlier this paper stems from a broader study into regional land use and site patterning for the purpose of developing models applicable to archaeology. Data on game hunting and preparation is most likely to appeal primarily to archaeologists. While often willing to apply ethnographic analogies in their interpretations of archaeological debris, archaeologists are rightly cautious about assuming directly analogous associations between behaviour and debris when the two are separated by space, time, and environments. There is an undertandable preference for deriving analogies from a similar environmental context to the original environmental context of the archaeological materials.

The Garawa material provided here, although general, contributes to the very limited data base available for transitional sub-humid to semi-arid environments. In so doing it also supports the hypothesis that, within Australia, basically similar strategies for game exploitation often existed across differing environments. If such similarities can be identified over space it may be feasible to suggest that common strategies also existed over time. This hypothesis requires further testing through more detailed comparative studies. It cannot be denied though, that the generation of models of behaviour — social, economic or technological — on the basis of the identification of regularities in behaviour within and between regions, can be of considerable value in the interpretation of archaeological models. Binford (1983), for example, has applied the results of his own

ethnographic work amongst the Nunamiut of northern America to the interpretation of the archaeology of the French Palaeolithic. The Australian record has the potential to contribute to the development of behavioural models applicable to both Australian and overseas studies. To do so, though, it must first modify its tendency to over-emphasise specifics. As Clarke has stated (1978: 100):

> This specification problem is the single greatest barrier in detecting significant correlations between regularities in archaeological and anthropological analyses . . .

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FIRST HEXACTINELLIDA (PORIFERA) (GLASS SPONGES) FROM THE GREAT AUSTRALIAN BIGHT

HENRY M. REISWING

Summary

The four species of Hexactinellida described are the first members of the class reported from southern Australian shelf and slope waters. The large vasiform Pheronema amphorae n. sp. is the first known member of the genus outside the Atlantic region bearing a well-developed annulus. Euplectella regalis, previously known only from the holotype, is represented by two new individuals. A very large specimen of Regadrella okinoseana, exhibiting the extremely rare feature of sieve plate fusion, offers new data which permits synonymisation of all stauractin-bearing regadrellids.

FIRST HEXACTINELLIDA (PORIFERA) (GLASS SPONGES) FROM THE GREAT AUSTRALIAN BIGHT

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REISWIG, H. M. 1992. First Hexactinellida (Porifera) (glass sponges) from the Great Australian Bight. *Rec. S. Aust. Mus.* **26**(1): 25-36.

The four species of Hexactinellida described are the first members of the class reported from southern Australian shelf and slope waters. The large vasiform *Pheronema amphorae* n. sp. is the first known member of the genus outside the Atlantic region bearing a well-developed annulus. *Euplectella regalis*, previously known only from the holotype, is represented by two new individuals. A very large specimen of *Regadrella okinoseana*, exhibiting the extremely rare feature of sieve plate fusion, offers new data which permits synonymisation of all stauractin-bearing regadrellids.

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Knowledge of the hexactinellid sponge fauna is rudimentary in all but a very few marine communities. Few are more inadequately documented than that of the continental shelves and slopes of the south and west coasts of Australia. Only two major oceanographic expeditions have sampled in or near these waters. In 1874 H.M.S. 'Challenger' collected four new species (Schulze 1887), all from oceanic stations well south of the continent (Fig. 1) — Sta. 157: *Holascus polejaevi* Schulze and *Caulophacus pipetta* (Schulze) (as *Balanella*); Sta. 158: *Hyalonema conus* Schulze; Sta. 160: *Holascus fibulata* Schulze. During the British, Australian and New Zealand Antarctic Research Expedition (BANZARE), the R.R.S. 'Discovery' passed over the shelf in 1930 and offshore in 1931. While results of work on the BANZARE Antarctic sponges have been published, those on the Australian and subantarctic sponges, planned for a separate account (Koltun 1976), remain unreported.

This report thus represents the first published record of identified Hexactinellida from the continental shelf and slope waters of southern Australia. The four species were collected at separate stations in the Great Australian Bight (Fig. 1) by F.V. 'Adelaide Pearl' and F.V. 'Saxon Progress' during July and August 1988. The specimens, which were kindly made available for study by Shane Parker, Curator of Lower Marine Invertebrates, South Australian Museum (SAM), are now in the permanent collections of that institution.

Systematic Descriptions

Class Hexactinellida Schmidt, 1870
Subclass Amphidiscophora Schulze, 1899
Order Amphidiscosida Schrammen, 1924
Family Pheronematidae Gray, 1870

Genus *Pheronema* Leidy, 1868

Diagnosis

Schulze (1904) (emended): body form usually cup- or bowl-like with a distinct gastral cavity, but extremes include plate and spherical shapes; gastral margin usually defined by a complete or incomplete fringe of marginal prostalia; lateral body surfaces bear long pleural prostalia singly or in tufts; basal prostalia project from the inferior body surface in numerous distinct bundles but occasionally as single spicules or in a single bundle; large prostalia are exclusively monactins, either sceptres or bidentate anchors with strongly or gently recurved flukes; smaller macruncinates are components of all prostalia bundles; basal rays of pinules are straight and oriented perpendicular or slightly oblique (downward) to the pinular ray.

Pheronema amphorae n.sp.
(Figs 2-4)

Material Examined

Holotype: SAM S696, continental shelf, 183 km south of Cape Adieu, South Australia, 33° 42′S, 132° 25′E, 130 m depth, 12 August 1988, coll. B. Jubb, F.V. 'Saxon Progress', Sta. C4, trawl, in ethanol.

Diagnosis

Pheronematid with deep cup-shaped, nearly tubular body. Large terminal osculum bordered by fringe of sceptres as marginalia and encircled a short distance below by an annulus of long sceptres as pleuralia. Thorned, gothic-arched basalia, 126-264 μm across the anchor, project from the lower half of body in distinct bundles. Uncinates in four distinct size classes ranging from 168 to 1816 μm, in mean length. Microscleres include two size classes of amphidiscs, spiny oxyhexactins and oxypentactins, and siliceous 'pearls'.

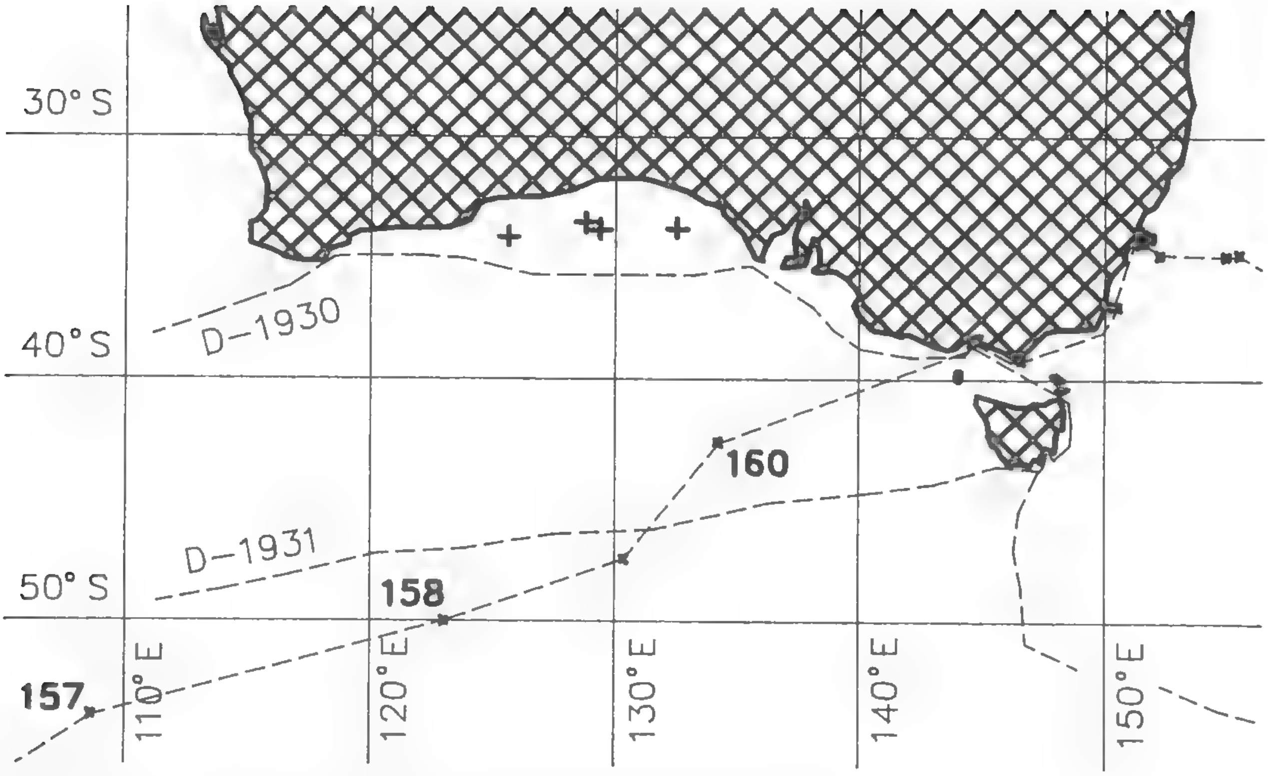


FIGURE 1. Map of southern Australian waters with collection stations reported here (+) and tracks of 'Challenger' (with station numbers), and 'Discovery' (equal longitude/latitude computer projection).

Description

Morphology: The only specimen, moderately damaged during collection with loss of much of the oscular margin (Figs 3 and 4), is reconstructed in Fig. 2a. The body is vasiform or almost tubular, with dimensions: 22 cm length, 13 cm diameter, 7 cm oscular diameter, and 1.8-3.2 cm wall thickness. The texture is soft and fragile, with internal structure visibly cavernous. The oscular marginal fringe, projecting 1.3-2.5 cm, consists mainly of large sceptres in bundles of 5 to 20 spicules. Most are 70-100 μm in diameter and broken distally, so they remain as smooth shafts with acute internal ends. Their monactin nature is established by associated younger developmental stages. Macruncinates comprise approximately 10% of the fringe spicules.

The external surface is generally smooth in overall contour and consists of four recognizable zones (Fig. 2a): a felt zone approximately 2.5 cm wide bordering the marginal fringe, an annular zone of long sceptres *ca* 0.5 cm wide, a 'smooth' zone extending over the remainder of the upper one-half of the body, and a basal zone extending over the lower body half.

The felt zone is covered by a dense nap of vertically oriented spicule bundles, extending 0.2 cm above the body surface. The bundles consist of short, thin sceptres (85%, 10-25 μm diameter) and macruncinates (15%). Few dermal pinules cover the surface between bundles. The annular zone, like the marginal fringe, consists of very large, often broken sceptres, up to 160 μm diameter, projecting up to 5 cm, with spicules of the felt level continuing as a lower stratum. A few very long, thin 'silk' spicules, 7 μm diameter by 10+ cm in length with broken distal tips, project with the longer sceptres. The smooth zone is bounded by a porous surface covered by dermal pinules with a sparse population of the small sceptres and macruncinates of the felt zone persisting. Long thin basalia occur occasionally in this zone, projecting 5-15 cm singly or in small groups of up to five. The basal zone includes components of the smooth zone with addition of basal anchor bundles spaced 0.5-1 cm apart. The bundles are 0.2-0.4 cm in diameter and consist of 10 to 50 basal anchors of all sizes, with single spicules reaching over 300 μm diameter. The basal terminus of the body is bare of root bundles. A few sceptres up to 3 cm long also occur in the root bundles. Bundles, up to 32 cm in length, intertwine to form a massive anchor mass. In natural position these probably radiate evenly through a hemisphere of bottom sediment.

The gastral surface is smooth and even, covered only by a layer of gastral pinules. There are no openings of large exhalant canals nor indication of a special gastral sieve.

Megascleres (Table 1): No proper diactine megascleres (uncinates excluded) occur in this species, as characteristic of the genus. Large pentactins (not figured) serve as parenchymal principalia as well as hypodermalia and hypogastralia. They are smooth-

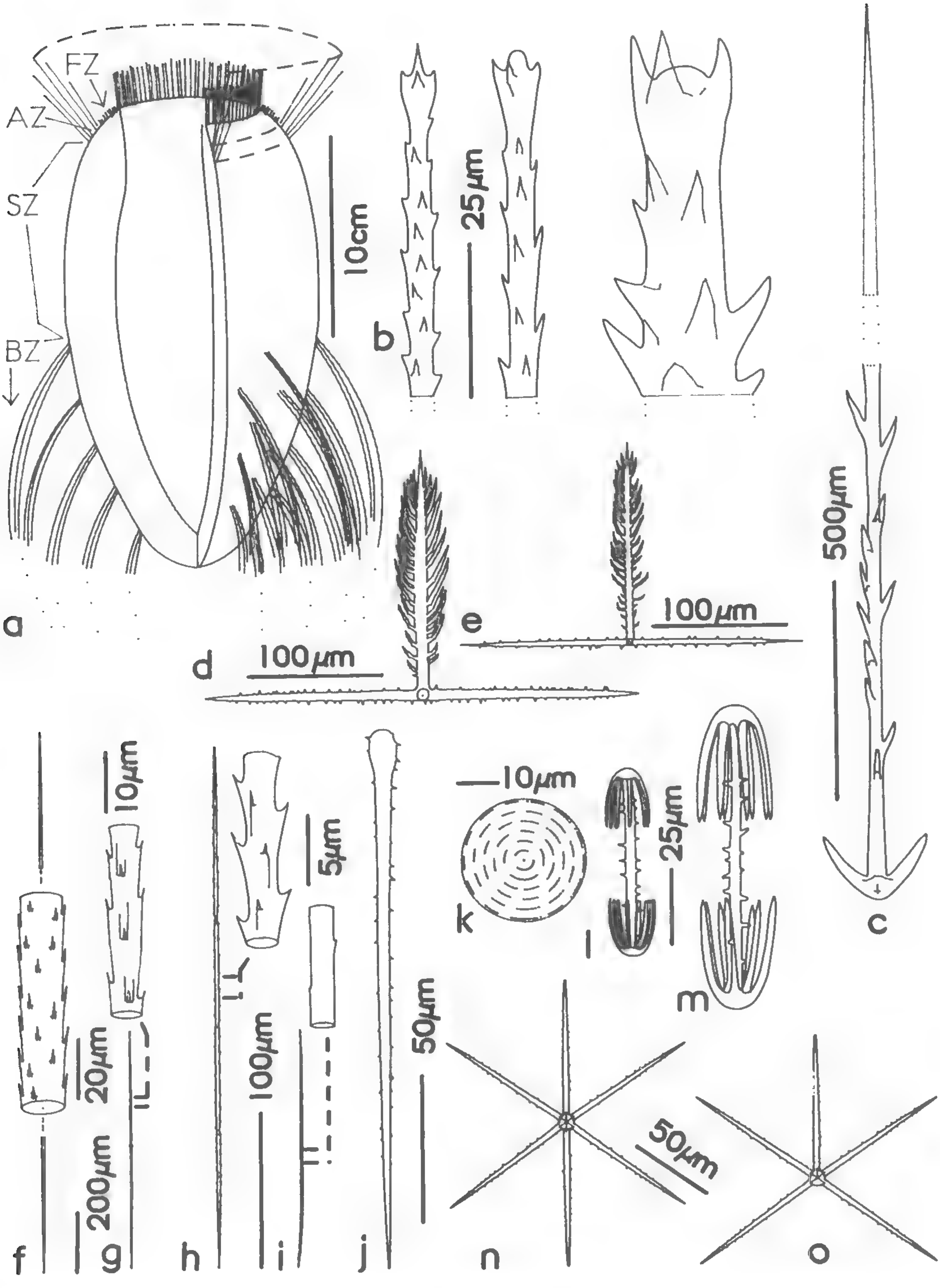
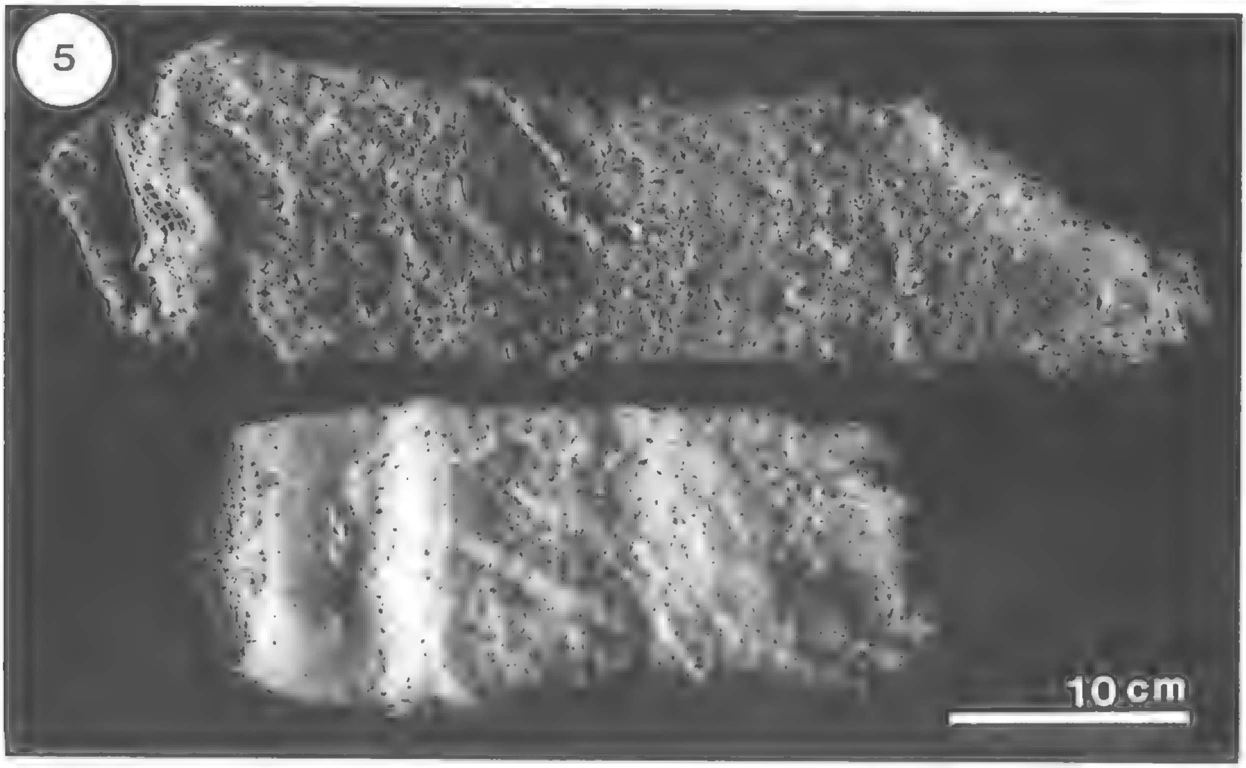


FIGURE 2. *Pheronema amphorae* n. sp. holotype SAM S696. **a**, reconstruction of body form with external zonation (see text for explanation); **b**, sceptre tips; **c**, basal anchor; **d**, dermal pinule; **e**, gastral pinule; **f-i**, uncinates 1-4; **j**, monactine club; **k**, siliceous 'pearl'; **l**, micramphidisc; **m**, mesamphidisc; **n**, spiny mesohexactin; **o**, spiny mesopentactin.


3
10 cm


4


5
10 cm

surfaced and either regular when associated with body surfaces or irregular when parenchymal. Monactine sceptres, or 'cuspidates', (Fig. 2b) occur as a major component of dermal spiculation, including the marginal fringe and annulus. Younger (shorter) sceptres have distal spines directed outwards toward the spicular centrum with only the proximal quarter of the shaft smooth. As spicules increase in size the relative proportions of shaft texture are gradually reversed until, in the largest intact examples, spination is restricted to a small distal section. Uncinates were divided into size classes by preliminary size-frequency analysis of 600 random length measurements. The two larger sizes (Figs 2f and g) have straight shafts and distinct barbs. The smaller classes (Figs 2h and i) both lack barbs at the light microscope level; the larger of the two is straight-shafted and bears sharp spines while the smallest is distinctly curved and carries only bracket facets. Basalia (Fig. 2c) have typical bidentate anchors and coarsely thorned distal shafts. The anchor is of the gothic arch form. No smooth-shaft basalia are present, thorns being especially pronounced at the earliest formative stages. Thin filiform spicules or 'silks', *ca* 7μm in diameter, are present in low abundance in the annulus. They bear sharp proximal tips but are universally broken distally. Slight swellings at regular intervals along the shaft of some examples are interpreted as incipient thorns. These are probably monactins, as are all other prostalia, but of uncertain taxonomic significance.

Mesocleres (Table 1): Recognition of this major category of spicule is forced by similarity of form and size between pinules, usually categorized as megascleres, and parenchymal hexactins, usually categorized as microscleres (*e.g.* microhexactins). Spicule dimensions alone are inadequate to define major spicule categories within Hexactinellida as evident in the range of uncinate size classes above. Dermal and gastral pinules (Figs 2d and e) have typical fir-tree pinulus and perfectly perpendicular and completely spined tangential rays. A few exhibit curvature and reduced spination of the pinular ray, but these variations are rare. Mesoxyhexactins and mesoxypentactins occur as typical parenchymal intermedial spicules (Figs 2n and o). They are completely covered in short spines, and thus intergrade with pinule variants exhibiting reduction of pinulus spination. The distinction between these classes remains nonetheless obvious. Spined monactine clubs (Fig. 2j), or acanthotylostyles in demosponge terminology, occur sparsely as parenchymal intermedials. While uncommon, they are sufficiently abundant and consistent in form to warrant recognition as a distinct spicule type in this species. They may be of rare occurrence in the wider group, Hexactinellida.

Microscleres (Table 1): Amphidisc classes were

TABLE 1. Spicule dimensions of *Pheronema amphorae* n. sp. in μm unless otherwise noted.

Spicule type	Length ± SD	(range)	N	Width ± SD	(range)	N
Macropentactin						
tangential ray	3685±2000	(547-8533)	50	46.7±13.7	(21.6-75.1)	50
unpaired ray	2747±1493	(543-6537)	50	–	–	–
Sceptre	to 6+ cm	–	–	to 160 μm	–	–
Uncinate 1	1816±337	(1217-2749)	50	13.6±2.3	(8.5-19.0)	50
Uncinate 2	796±174	(533-1293)	50	5.8±1.4	(3.5-11.0)	50
Uncinate 3	342±95	(178-621)	50	2.4±0.6	(1.3-4.5)	50
Uncinate 4	168±52	(73-281)	50	1.5±0.3	(1.0-2.5)	50
Basal anchor	to 32+ cm	–	–	216±27*	(126-264)	50
Silk	to 10+ cm	–	–	–	(7.0-8.3)	–
Dermal pinule, pinulus	144±32	(83-242)	50	8.5±1.4	(5.7-11.6)	50
tangential ray	130±20	(87-186)	61	7.1±1.1	(5.0-9.7)	50
Gastral pinule, pinulus	124±30	(61-251)	67	6.9±1.1	(4.2-10.8)	50
tangential ray	129±18	(72-172)	61	6.3±1.1	(3.7-10.5)	50
Mesoxyhexactin ray	95±19	(64-154)	66	3.3±0.5	(2.7-4.4)	25
Mesoxypentactin ray	99±20	(58-166)	66	3.5±0.8	(2.1-4.7)	25
Monactine club	169±32	(119-314)	45	–	–	–
Mesamphidisc	102±11	(88-138)	50	24.8±3.9	(19.2-37.7)	50
Micramphidisc	60±7	(45-77)	50	15.7±2.7	(11.3-23.1)	50
Pearl (diameter)	31.2±12.4	(15.8-82)	50	–	–	–

* widest distance between anchor teeth tips.

◄

FIGURES 3-5. *Pheronema amphora* n. sp. and *Euplectella regalis.* **3 and 4**, internal (left) and external (right) views of *Pheronema amphorae* holotype, SAM S696; **5**, *Euplectella regalis*, SAM S693 (upper) and S694 (gross external transverse ridges are artefacts of the packaging process for specimen transport).

identified by length-frequency analysis of 754 randomly selected spicules; a clear bimodal distribution was obtained. Mesamphidiscs (Fig. 2m) have elongate 8-toothed umbels and a mean width/length ratio of 0.260. Micramphidiscs (Fig. 2l) have proportionately shorter and narrower umbels bearing 9-*10.5*-13 teeth and a mean width/length ratio of 0.243. Both amphidiscs are distributed throughout the parenchyme and dermal tissues, but are not common in near-gastral tissues. Extensive search for intrinsic macramphidiscs yielded negative results. Spherical 'pearls' (Fig. 2k) of obvious intrinsic production were sufficiently common to accept these as a recognizable skeletal element in this specimen.

Etymology

The name refers to the body form, which resembles the basal portion of an amphora.

Remarks

Schulze's (1904: 151) definition of *Pheronema* excludes the species assigned to *Poliopogon* at that time and is here considered valid. Ijima's (1927: 9) suggestion to move *Poliopogon gigas* Schulze to *Pheronema* is rejected because supporting arguments were not presented. Tabachnick (1988) supported Ijima's suggestion, without assignment of *P. gigas*, and attempted to redefine *Poliopogon*. His redefinition must be ignored since it neglects consideration of principalia, pleuralia, marginalia, and uncinates altogether and, as proposed, would exclude the type species *Poliopogon amadou* Thomson. More recently (Tabachnick 1990) he reassigned *P. gigas* as the type of a new genus, *Schulzeviella*, which differs from *Poliopogon* by body form and presence of microxydiacts. In view of the great variability of body form and microsclere complement accepted for *Pheronema*, these characters seem inadequate for distinction of genera. A revision of the relationship between the three genera must include a thorough and informed review of all species involved.

The genus *Pheronema*, understood to exclude *Poliopogon gigas*, contains 19 species and one subspecies which presently hold nomenclatural validity, although the genus has not been revised and some are probably synonyms. Most are easily compared to *P. amphorae* but a few are inadequately known due to the poor state of the material available to the describer, or to the lack of diligence by the original author. The single character, body form, distinguishes *P. amphorae* from all other species, but alone is insufficient for taxonomic action. The abbreviated inventory of additional character differences presented here is adequate to demonstrate the distinction of the new species. Principalia include hexactins in *P. conicum* Lévi & Lévi (1982), *P. pepo* Ijima & Okada (1938), and *P. placodium* Ijima & Okada (1938), but are exclusively pentactins in *P. amphorae*. The basal anchor is crescentic in *P. conicum*, *P. echinatum* Ijima (1927), *P. giganteum* Schulze (of Schulze 1886, not Ijima 1927), *P. hemisphaericum* (Gray 1873), *P. ijimae* Okada (1932) (of Lévi & Lévi 1989, not Okada 1932) but gothic-arched in *P. amphorae*. Anchor form was not given in descriptions of *P. barbulosclera* Lévi (1964), *P. pilosum* Lévi (1964), *P. semiglobosum* Lévi & Lévi (1982), and *P. surugensis* Okada (1932). Forms lacking marginalia are *P. annae* Leidy (1868), *P. gigantea* (of Ijima 1927, not Schulze 1886), and *P. ijimae*. Spiny mesoxyhexactins are abundant in *P. amphorae* but are absent in *P. carpenteri* (Thomson 1869), *P. globosum globosum* Schulze (1886), *P. grayi* Kent (1870) and *P. megaglobosum* Tabachnick (1988). A sieve plate, lacking in *P. amphorae*, is present in *P. globosum kagoshimensis* Okada (1932), *P. raphanus* Schulze (1894), *P. semiglobosum*, and *P. nasckaniensis* Tabachnick (1990). Micramphidiscs are much smaller than those of *P. amphorae* (entirely outside the range) in *P. barbulosclera*, *P. giganteum*, *P. globosum globosum*, *P. raphanus*, *P. surugensis* and *P. weberi* Ijima (1927). All of these species differ from *P. amphorae* in several other characters. *Pheronema pilosum* remains the most difficult member to compare with the new species due to brevity of its original description (Lévi 1964). Differences in body form, dimensions and spination of dermal pinules, and amphidisc sizes indicate the two forms are quite distinct, but form and size of basal anchors and presence or absence of mesoxyhexactins remain unknown for *P. pilosum*. The new species is most closely related in body form and overall spiculation to *P. carpenteri* and *P. grayi* of the North Atlantic.

The nominal taxa, *P. parfaiti* Filhol (1885) and *P. saccus* Schmidt (1870), must be considered unrecognizable, as concluded by Schulze (1904), until the original specimens are found and their characters assessed. Schulze's (1893) argument that *P. pourtalesii* Schmidt (1870) must be referred to *Rossella* is accepted here. *Pheronema circumpalatum* Schulze (1894), as affirmed by Schulze (1902), is a junior synonym of *P. raphanus*. *Pheronema velatum* is a nomen nudum. It was used without description or indication by Carpenter & Jeffreys (1870) as a provisional name for a Gibraltar specimen later figured as *Rossella velata* by Thomson (1873), now the only recognized species of *Mellonympha*.

Distribution

Great Australian Bight, 130 m depth.

Subclass Hexasterophora Schulze, 1899
Order Hexactinosida Schrammen, 1910-12
Suborder Clavularia Schulze, 1886
Family Farreidae Schulze, 1886

Genus *Farrea* Bowerbank, 1862

Diagnosis
See Ijima (1927: 130).

Farrea occa occa Bowerbank, 1862, Carter, 1885

Abbreviated synonymy:
unnamed – Owen, 1857: 121 pl. XXI figs 9, 9a.
Farrea occa Bowerbank 1862: 1118; 1864: 204, pl. XX, fig. 311 (not pl. XV, fig. 277); 1869: 339 pl. XXIV, fig. 7 (not figs 1-6); Carter 1885: 388 pl. XII, pl. XIII, figs 1-11; Schulze 1887: 277 pl. LXXI-LXXII, LXXVI.
Farrea occa occa Ijima 1927: 131; Burton 1959: 153; Reiswig 1990: 735.

Material examined
One specimen (fragments): SAM S813, continental slope, 232 km east of Cape Arid, Western Australia, 34°03′S, 125°31′E, 1 011-1 020 m depth, 31 July 1988, coll. K. L. Gowlett-Holmes, K. J. Olsson and M. Cameron, F. V. 'Adelaide Pearl', Sta. 15, trawl, in ethanol.

Description
The specimen consists of three main fragments, two of which retain soft tissues, plus numerous small fragments, all presumably from a single original specimen. The largest fragment, 2.8 cm in height by 1.8 cm width, is composed of thin-walled tubules 0.7 to 1.0 cm in diameter, similar to the Japanese specimen of Carter's (1885) redescription. The frame is primarily single layered and square meshed, with conspicuous asymmetry in length of spurs on the two faces. Spiculation includes dermal and gastral spined pentactins, oxyhexasters (99-119 μm diameter) which are often hemihexastrous and merge with oxyhexactins, and pileate clavules projecting in radial bundles in the dermal layer. Terminal rays of the oxyhexasters are longer than primary rays in the ratio 1.3. No tylohexasters or other forms of clavulae are present.

Remarks
On the basis of body form and spiculation, the specimen is assigned to the typical subspecies *Farrea occa occa* in spite of slight differences in proportions of the oxyhexasters and absence of anchorate clavules.

Distribution
Cosmopolitan

Order Lyssacinosida Ijima, 1927
Family Euplectellidae Gray, 1867
Subfamily Euplectellinae Ijima, 1903

Genus *Euplectella* Owen, 1841

Diagnosis
See Ijima (1927: 327).

Euplectella regalis Schulze, 1900
(Figs 5-8)

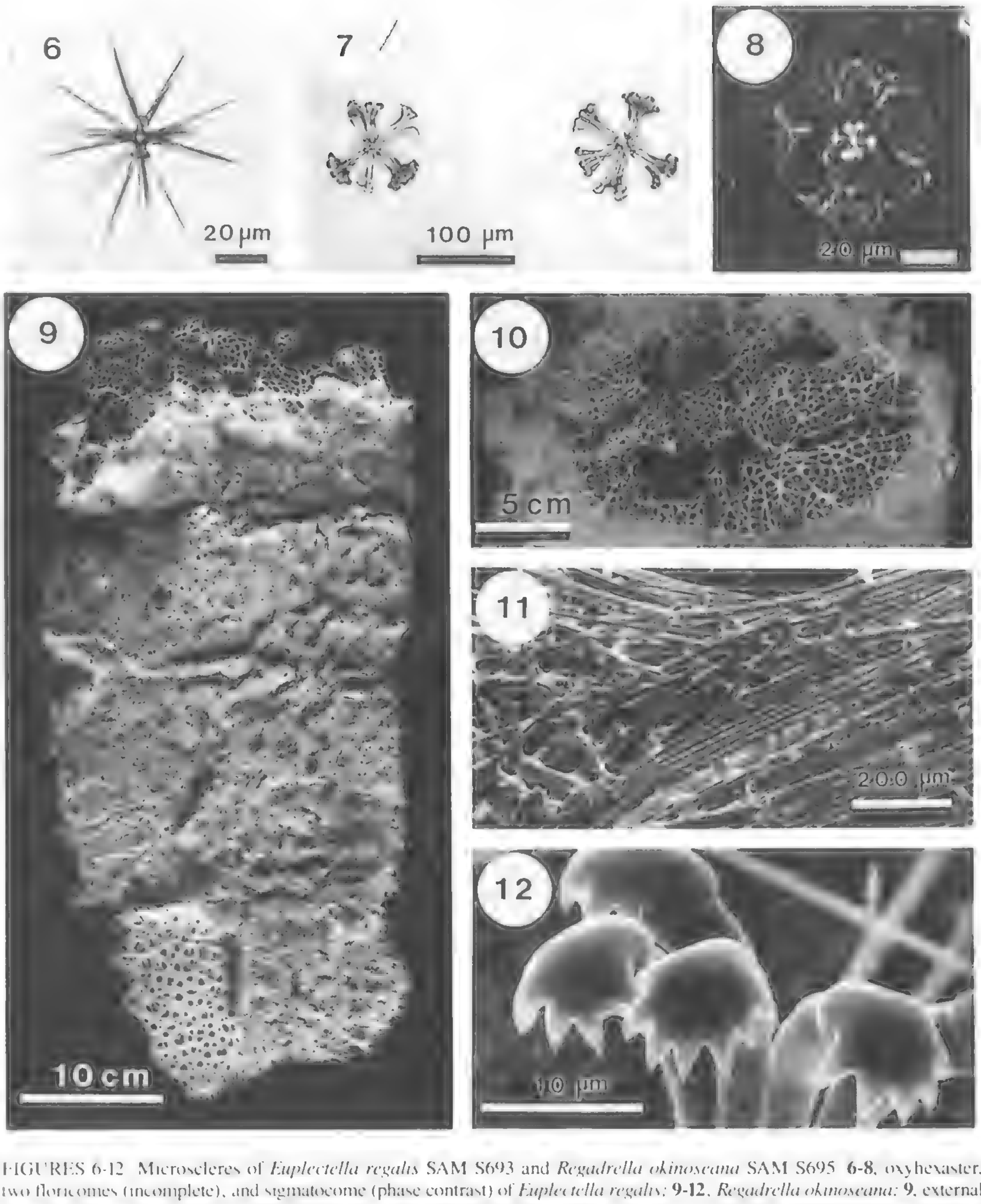
Euplectella regalis Schulze 1900: 24, pl. VI, figs 1-9; 1902: 61, pl. XXII, figs 1-9, 1904: 132 (key); Ijima 1901: 58 (key); 1927: 327, 334; Burton 1959: 154; Reiswig 1990: 738.

Material examined
Two specimens: SAM S693, SAM S694, continental slope, 194 km south of Eucla, South Australia, 33°26.8′S, 128°41′E, 956-973 m depth, 28 July 1988, coll. K. L. Gowlett-Holmes, K. J. Olsson and M. Cameron, F.V. 'Adelaide Pearl', trawl, in ethanol.

Diagnosis
Euplectellidae with straight, cylindrical body; with nearly flat sieve plate bordered by a narrow marginal collar; local patches of parietal oscula in oblique or longitudinal and transverse rows; soft parietal ridges run obliquely; parietal principalia are stauractins with diactins and triactins as comitalia; oscularia are mainly stout pentactins; microscleres include oxyhexasters with short primary rays, floricomes with 3-to-10-toothed, palmate tips, sigmatocomes, and graphiocomes.

Description
Morphology: The two flattened specimens (Fig. 5) are the soft, flexible upper portions of cylindrical individuals of unknown total length. Their respective dimensions (693, 694) are: length 41, 29.5 cm; diameter 8.0, 8.3 cm. Both have narrow marginal collars, 0.65-0.8 cm and 0.63-0.75 cm in width and well developed but soft and thin, oblique parietal ridges to 1.3 cm and 1.15 cm height respectively. Wall thickness varies from 0.30-0.45 cm in both specimens. Parietal oscula are irregularly distributed – in some areas in oblique series and in others in longitudinal and transverse rows. The sieve plates are nearly flat and typical in form. Synapticular fusion is evident only in the lower portions of both specimens.

Spiculation: Parietal principalia are tetractins (stauractins), with associated diactins, triactins, and few hexactins as comitalia. The sieve plate contains stout bent macrodiactins and a few macrotriactins and macrotetractins as principalia, long diactins and triactins as commitalia and short, stout pentactins and hexactins as superficial spicules. Sword hexactins and diactins form the major support elements in the general dermis, marginal collar, and parietal ridges. Parietal oscularia consist mainly of small stout pentactins (62%), but hexactins (26%), tetractins (6.5%), triactins (2.2%) and compass diactins (3.3%) occur (N=346). Four classes of microscleres are common – dimensions are based upon 25 spicules of each (693, 694; min-*mean*-max). Oxyhexasters (Fig. 6) have very short principal rays, 0.125 of radius, and 2-*3*-4



FIGURES 6-12. Microscleres of *Euplectella regalis* SAM S693 and *Regadrella okinoseana* SAM S695. **6-8**, oxyhexaster, two floricomes (incomplete), and sigmatocome (phase contrast) of *Euplectella regalis*; **9-12**, *Regadrella okinoseana*: **9**, external view, **10**, broken sieve plate, **11**, SEM of sieve plate beam showing synapticular fusion; **12**, SEM of floricome terminal ray tips.

terminals: 82-*95*-110, 86-*111*-128 μm diameter. Floricomes (Fig. 7) have 3-*7*-10 terminals: 90-*108*-124, 89-*120*-133 μm diameter. Sigmatocomes (Fig. 8) have 10-*12*-14 terminals: 49-*56*-76, 48-*60*-67 μm diameter. Graphiocomes are broken in all preparations: centra 21-*26*-30, 15-*21*-24 μm diameter; raphide terminals 110-*129*-147, 69-*113*-154 μm length. Anchors are unavailable.

Remarks

These specimens are excluded from the fourteen other valid species of *Euplectella* by nature of parietal and sieve plate principalia, parietal ridges, marginal collar, oscularia and presence of oxyhexasters. They agree with all major characters of Schulze's (1900) *Euplectella regalis* but differ in two details, the presence of graphiocomes (as predicted by Ijima 1901: 53), and the distribution pattern of parietal oscula (described as generally in longitudinal and transverse rows in the type specimen, Schulze 1900: 24). Only a small portion of the type of *E. regalis* is figured by Schulze (1900), so verification of his description of oscula distribution would require re-examination of the original specimen. Unfortunately that specimen may be too severely subdivided to resolve the pattern of oscula (2 jars with 3 pieces in the Natural History Museum, London; 3 jars in the Zoologisches Museum der Humboldt Universität, Berlin; main specimen probably in the Indian Museum, Calcutta). In spite of this slight difference, the two specimens are here accepted as the second and third known examples of the species. Both Australian sponges were probably larger than the type specimen which was complete with root tuft and measured 40 cm in length and 7-8 cm in diameter. The tendency for local areas of body wall to develop distribution of parietal oscula in longitudinal and transverse rows is accepted here as a variable character, along with slight differences that are expected to occur in proportions and dimensions of spicules. An emended diagnosis reflects these variations.

Distribution

Andaman Is., 741 m; Great Australian Bight, 956-973 m.

Subfamily CORBITELLINAE Ijima, 1902b

Genus *Regadrella* Schmidt, 1880

Diagnosis

See Ijima (1927: 335).

Regadrella okinoseana Ijima, 1896
(Figs 9-12)

Regadrella okinoseana Ijima 1896: 250; 1901: 223, pls VII, VIII; 1902a: 122; 1902b: 8; 1902c: 691; 1903: 18; 1927: 335; Schulze 1899: 115; 1900: 30; 1902: 67; 1904: 133; Topsent 1904: 375; 1928: 297; Wilson 1904: 35; Schrammen 1912: 182; Kirkpatrick 1913: 64; Reid 1964: cxxvii; Lévi & Lévi 1982: 292, pl. VI; Salomon 1990: 344; Reiswig 1990: 738.
Regadrella decora Schulze 1900: 30, pl. VI, figs 10-18; 1902: 67, pl. XXII, figs 10-18; 1904: 133; Ijima 1901: 223; 1927: 335; Burton 1959: 154; Lévi & Lévi 1982: 293; Reiswig 1990: 738.
Regadrella cylindrica Ijima 1927: 335, pl. VIII, figs 9-21; Reid 1964: xcii; Lévi & Lévi 1982: 293; Salomon 1990: 344; Reiswig 1990: 738.

Material examined

One specimen: SAM S695, continental slope, 232 km south of Eucla, South Australia, 33°45′S, 129°17′E, 999-1110 m depth, 1 August 1988, coll. K. L. Gowlett-Holmes, K. J. Olsson and M. Cameron, F. V. 'Adelaide Pearl', trawl, in ethanol.

Diagnosis

Regadrellid with barrel-shaped body, slightly inflated sieve plate, wide marginal collar (cuff) and rigid, fused basal cup attached to solid substrate; lateral body wall bearing a connected network of smooth-edged ridges which circumscribe depressions containing small parietal oscula; principalia are large gently bent diactins; microscleres include distinctive oxystauractins, floricomes, and graphiocomes.

Description

Morphology: The specimen (Fig. 9) consists of the upper portion of a large individual of unknown total length. It is 48 cm in length and, although now flattened, was presumably oval in cross section, with major and minor diameters measured at the upper end of 22.9 by 14.5 cm. The marginal collar is well developed, up to 2.5 cm wide, and the ridges between the parietal depressions are *ca* one cm in height. Synapticular fusion of lateral wall spicules is absent from the upper 33 cm, and gradually increases from that point towards the torn basal end. The sieve plate, originally nearly flat in shape, is extensively broken due to synapticular fusion of the central half (Figs 10 and 11). Synapticular deposition gradually decreases marginally. The area bounding the junction with the body wall remains free of all but trivial traces of secondary silicification and is flexible.

Megascleres and mesoscleres (dimensions as min-*mean*-max, n=25): The principalia are large curved diactins to 6.2 cm long by 214 μm width. They are accompanied by diactin comitalia and intermedial oxyhexactins. Three classes of dermalia are present. Large sword hexactins in the parietal ridges and marginal collar have tangential rays 130-*185*-244 μm, distal rays 171-*512*-788 μm, and proximal rays 301-*852*-1765 μm in length. Smaller dermals have tangential rays 131-*261*-391 μm, distal rays 64-*125*-233 μm but proximal rays either short 47-*144*-346 μm, or

long 352-*492*-683 μm. Gastralia are the usual pentactins (not measured). Mesoscleres consist of thick-rayed hexactins and pentactins covering sieve plate beams and spiny intermedial oxyhexactins with rays 104-*158*-192 μm in length, the latter uncommon.

Microscleres: Oxystaurasters with three (rarely five) terminals are the most abundant microsclere, 73-*94*-117 μm in diameter. Variants occur as pentasters (6%), triasters (<1%), hexasters (<1%), and octasters (<1%). Floricomes bearing eight terminals per primary are common in dermal structures, 115-*131*-147 μm in diameter. Terminal expansions carry 3-*6-7*-8 recurved claws (Fig. 12). The presence of graphiocomes verified by their characteristic centra, 30-*35*-43 μm in diameter, and abundant raphide terminals, 167-*196*-242 μm in length.

Remarks

The specimen generally agrees with the descriptions of *Regadrella okinoseana* from Sagami Bay, Japan, by Ijima (1896, 1901) and from New Caledonia by Lévi & Lévi (1982), but differs in a few features. The principalia of the present specimen attain much larger dimensions than those of either of the other two known localities, but this is explained by the larger size and presumably greater age of the South Australian specimen – the largest from Sagami Bay was 42 cm and from New Caledonia 29 cm in total length for intact individuals. The floricomes of the present specimen are larger (mean 131 *vs* 98-107 μm at Sagami Bay and 90 μm at New Caledonia) and carry more terminal spines (usually 6-7 *vs* 2-3 at Sagami Bay and undescribed at New Caledonia). The spiny mesohexasters are larger than the Japan specimens (104-192 *vs* 55-150 μm ray length), but of the same mean size as those from New Caledonia. These differences are accepted as within the range of geographic variation of a species and are not considered adequate for recognition of even varietal status.

Only three species of *Regadrella* contain oxystaurasters as characteristic microscleres, *R. okinoseana*, *R. decora* Schulze, 1900, from near Cape Comorin, Indian Ocean, and *R. cylindrica* Ijima, 1927, from north of Celebes. Review of Schulze's description of *R. decora* suggests that his recognition of this as distinct from *R. okinoseana* was based upon Ijima's poor original description and Schulze's misinterpretation of same. The only differences between these appear to be the lack of oxyhexasters and more angular nature of principalia in *R. decora*, both of which appear to be of dubious value since the oxyhexasters are rare and the principalia are clearly curved in *R. okinoseana*. The distinction between *R. okinoseana* and *R. cylindrica* is equally tenuous, based again on the absence of oxyhexasters, the lack of spiny microxyhexasters, and the greater size of oxystaurasters in the latter. The first two differences are trivial since 'absence' of these uncommon spicule classes depends upon search effort, and the third distinction is slight, based on nonquantitative data, and is not deserving of even varietal importance, particularly with the greater overlap provided by the South Australian specimen. Both original authors were insecure in their assessment of the validity of the two later species, and recent authors (Lévi & Lévi 1982; Salomon 1990) have supported amalgamation of the stauractine-bearing *Regadrella* species. Synonymy of *R. decora* and *R. cylindrica* with *R. okinoseana* is supported by the data from the new specimen, and is here formally proposed.

Sieve plate fusion, present in this specimen, is extremely rare in lyssacine hexactinellids, and is apparently restricted to individuals of extreme age. It has never been documented by illustration. Chimmo (1878: 10) aluded to fusion of the sieve plate in *Euplectella aspergillum* Owen, without convincing microscopic evidence. Ijima (1902b: 4), an authority with extensive observational experience, provided a more convincing statement for *Corbitella speciosa* (Quoy & Gaimard). Tabachnick (1990: 169) reported synapticular fusion in the sieve plate of the 230 mm long holotype of *Regadrella peru* Tabachnick, but provided no photographic record. No other observation of sieve plate fusion is known in recent lyssacinosans. The rarity of extensive sieve plate fusion is appreciated since it presents a barrier to alteration of the central meshes. Potential for growth is retained by the lack of fusion at the marginal junction with the body wall. Synapticular fusion does enhance fossilization in these members of the lyssacine hexactinosans (Salomon 1990), a group otherwise poorly represented in the fossil record.

Distribution

Sagami Bay, Japan, 358-832 m depth; New Caledonia 390-505 m depth; SW of Cape Comorin, Indian Ocean, 787 m depth; N of Celebes, 1 165-1 264 m depth; Great Australian Bight, 999-1 110 m depth.

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NEW SPECIES OF ORIBATULIDAE (ACARIDA : CRYPTOSTIGMATA : PLANOFISSURAE) FROM SOUTH AUSTRALIAN SOILS, WITH A REVIEW OF SUBFAMILIES AND AUSTRALIAN RECORDS

D. C. LEE

Summary

Oribatulid mites from Australian soils are considered with comments on the subfamilies. Three new species, a new genus and a new species record are established for two subfamilies in South Australia as follows : Oribatulinae – Oribatula runcinata sp. nov., Zygoribatula cycloporosa sp. nov., Z. magna Ramsay; Pseudoppiinae – Aurosibula quagesetosa gen. nov. sp. nov. Of the nine florally diverse South Australian sites sampled, the new species and records are from only three sites with either a semi-arid, mallee-heath or pasture habitat. A key is provided for all six oribatulid species known from Australia. Oribatula caudata Berlese, 1910 is newly regarded as a synonym of Sellnickia caudata (Michael, 1908).

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D. C. LEE

LEE, D. C., 1992. New species of Oribatulidae (Acarida: Cryptostigmata: Planofissurae) from South Australian soils, with a review of subfamilies and Australian records. *Rec. S. Aust. Mus.* **26**(1): 37–49.

Oribatulid mites from Australian soils are considered with comments on the subfamilies. Three new species, a new genus and a new species record are established for two subfamilies in South Australia as follows: Oribatulinae – *Oribatula runcinata* sp. nov., *Zygoribatula cycloporosa* sp. nov., *Z. magna* Ramsay; Pseudoppiinae – *Ausoribula quagesetosa* gen. nov., sp. nov. Of the nine florally diverse South Australian sites sampled, the new species and records are from only three sites with either a semi-arid, mallee-heath or pasture habitat. A key is provided for all six oribatulid species known from Australia. *Oribatula caudata* Berlese, 1910 is newly regarded as a synonym of *Sellnickia caudata* (Michael, 1908).

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This is a further part of an ongoing study of sarcoptiform mites in South Australian soils, sampled from nine florally diverse sites, and for which an introduction to the relevant work on the advanced oribate mites (Planofissurae) has been published (Lee 1987). The classification of the Oribatulidae followed was initially that of Balogh & Balogh (1984). This was changed after the description of species of a number of oripodoid genera from or relevant to the Australian fauna (Lee 1987; Lee & Birchby 1989, 1991a, 1991b) led to the higher classification of the Oripodoidea, and so the included Oribatulidae, being modified (Lee 1991). The present paper outlines and adds to these changes to the oribatulid classification and also deals with three genera, from two subfamilies, from which three new species are described. A key is provided to distinguish all six oribatulid species known from Australia, completing the consideration of the Oribatulidae within this study.

The mites studied have either been deposited in the South Australian Museum (SAMA), the Field Museum, Chicago (FMNH), the Natural History Museum, London (BMNH), or the New Zealand Arthropod Collection, D.S.I.R. Auckland (NZAC), whilst the holotype of *Zygoribatula longiporosa* Hammer, 1953 has been returned to the Queensland Museum (QM). The morphological notational system follows Lee (1987), the somal chaetotaxy of which is summarised in Figs 1 and 2, with the total setae present in each file (*e.g.* 6Z) indicated by number coming first, whilst a particular seta (*e.g.* Z6) would have the number last. The abbreviations for zoogeographical regions follow Lee (1970, fig. 427). The descriptions of eggs refer to them whilst still within the female soma. All material was examined using a Normarski interference contrast device. Measurements are in micrometres (μm) and were made using an eyepiece micrometer at $\times$250 magnification.

SYSTEMATICS

Family ORIBATULIDAE Thor

Oribatulidae Thor, 1929: 184
Oribatulidae: Grandjean, 1954: 440
Oribatulidae: Coetzer, 1968: 15
Oribatulidae: Balogh & Balogh, 1984: 270

Nominotype: *Oribatula* Berlese, 1896

Diagnosis

Oripodoidea. Hysteronotal foramina multiporose. Dorsosejugal furrow present or absent. Lamella (between setae *z*1-*z*2) and translamella (between setae *z*1-*z*1), if present, either lamellate, costate or lineate. Other proteronotal ridges (sublamella, prelamella, tutorium or subtutorium) costate or lineate. Hysteronotum without pteromorph, although may have humeral process, and limbus usually inconspicuous. Ventrosejugal apodeme either complete or partial with mid-sternal gap. Preanal sclerite with breadth of lever half or less that of refractile cup-shaped caput. Femur I, and usually II, with medium-size stalk (length about 2$\times$ pedestal diameter), so that caput well separated from pedestal. Femur I and II each with 5 setae, seta *v*2 present. Tarsi I and II broad proximally (greater than 0.75$\times$ broadest part). Pretarsus with three claws. Larva with seta on anal shield, and solenidion on palp tarsus does not form 'corne double' with dorsal plasmic seta.

Remarks

The Oribatulidae were restricted when some genera were removed to establish Scheloribatidae (Grandjean, 1933), but this was not generally accepted until a revision of the Oripodoidea (as Oribatuloidea) by Balogh & Balogh (1984), where Scheloribatidae was

mistakenly referred to as a new family. In Balogh & Balogh's revision, the Oribatulidae were subdivided into four subfamilies, mainly on the basis of the number of genital setae. A subfamily that they ignored, Pseudoppiinae Mahunka, 1975, has since been redefined by Lee (1987) and, with a new subfamily, Fovoribatulinae Lee & Birchby, 1991a, extended the Oribatulidae to six subfamilies. Four of these subfamilies (Capilloppiinae, Crassoribatulinae, Fovoribatulinae and Sellnickiinae) have since been excluded from the Oribatulidae and they are considered briefly here.

The Fovoribatulinae Lee & Birchby, 1991a, when established, included new genera, *Brassiella* Balogh, 1970 (*ex* Fenicheliidae), *Reticuloppia* Balogh & Mahunka, 1966b (*ex* Oribatulinae) and *Romanobates* Feider, Vasiliu & Calugar, 1970 (*ex* Capilloppiinae). The subfamily was recognised by the absence of a seta (*av*2) on femur II. Later, this character state was considered as diagnostic of the primitive Crassoribatulid-complex (Lee 1991), many members of which are similar to the oribatulid species. Both Fovoribatulinae and Crassoribatulinae Balogh & Balogh, 1984 (ex Oribatulidae) were grouped in this Crassoribatulid-complex.

Both Sellnickiinae Grandjean, 1960 (mistakenly referred to as a new subfamily by Balogh & Balogh, 1984) and Capilloppiinae Balogh & Balogh, 1984 were excluded from the Oribatulidae to be included in either the Sellnickiid-complex or the Capilloppiidae (Mochlozetid-complex) by Lee (1991). This was mainly based on the shape of their preanal sclerites, but it has since been established (see following remarks) that the Capilloppiidae have a leg chaetotaxy and preanal sclerite as for members of the Crassoribatulid-complex and they are placed as a subfamily within the Crassoribatulidae.

The examination of the types of further oribatulid-like taxa, since the above changes were made (Lee 1991), has established that some of them lack seta *v*2 on femur II and they are, therefore, also here grouped in the Crassoribatulidae-complex. For these taxa, the setation of femur I and II is as follows: *Nesozetes rostropterus* Hammer, 1971 – femur I 1,2/1,0, femur II 1,2/1,0; *Capilloppia capillata* Balogh & Mahunka, 1966a – femur I 1,2/1,0, femur II, 1,2/1,0; *Lunoribatula polygonata* Mahunka, 1982 – femur I 0,2/1,0, femur II 0,2/1,0. Also the preanal sclerites of the types of *Capilloppia capillata* have a narrow lever and a refractile cup-shaped caput. Therefore, the new placings of these taxa, which have been grouped within or near to the Oribatulidae, are now within the Crassoribatulid-complex adding two subfamilies to that complex as follows: the Nesozetinae Balogh & Balogh, 1984 are grouped in the Lamellareidae Balogh, 1972 and the Capilloppiinae Balogh & Balogh, 1984, including *Lunoribatula*, are in the Crassoribatulidae Balogh & Balogh, 1984.

Key To Australian Oribatulid Species (Adults)

1 – Ventrosejugal apodemes continuous across midsternal line . . . . Oribatulinae 2
– Ventrosejugal apodemes do not merge across midsternal line . . . . Pseudoppiinae 5
2 – Translamella absent . . *Oribatula runcinata* sp. nov.
– Translamella present . . . . *Zygoribatula* 3
3 – Lamella and translamella broad, cuspis large (length about 5× diameter of setal base to *z*1). Behind interlamella seta (*j*2), ridge runs back to dorsosejugal furrow. First hysteronotal foramina (*F*3) oval (length 2× breadth), shorter than seta *Z*2 . . . . *Zygoribatula magna* Ramsay
– Lamella and translamella narrow, cuspis small (length about 2× diameter of setal base to *z*1) 4
4 – Behind interlamella seta (*j*2), ridge runs laterally to sensory seta (*z*2). First hysteronotal foramina (*F*3) spherical (length subequal to breadth). Head of sensory seta (*z*2) globular . . . . *Zygoribatula cycloporosa* sp. nov.
– Interlamellar seta (*j*2) without associated ridges. First hysteronotal foramina (*F*3) elongate (length about 10× breadth). Head of sensory seta (*z*2) pyriform . . . . *Zygoribatula longiporosa* Hammer
5 – Hysteronotum with 15 pairs of setae (6*J*, 6*Z*, 3*S*). Genital shield with two pairs of setae (2*JZg*) . . . . *Constrictobates lineolatus* Balogh & Mahunka
– Hysteronotum with 10 pairs of setae (2*J*, 6*Z*, 2*S*). Genital shield with four pairs of setae (4*JZg*) . . . . *Ausoribula quagesetosa* sp. nov.

Subfamily ORIBATULINAE Thor

Diagnosis

Oribatulidae. Ventrosejugal apodemes continuous across midsternal line. Hysteronotum oval, sometimes with humeral process, usually with 14 pairs of setae (exceptions: 10 pairs on *Paraphauloppia* and *Jornadia*, 12 or 13 pairs on some *Eporibatula*, *Oribatula* and *Zygoribatula* species), sejugal furrow not extending anterior to bothridium (around seta *z*2), always present across mid-line. Four pairs of multiporose hysteronotal foramina usually present (exception: three pairs on *Paraphauloppia triforamina*). Genital shield usually with four pairs of setae (exception: five pairs on *Jornadia*). Legs long and slim.

Remarks

The Oribatulinae included 14 genera in the classification of Balogh & Balogh (1984). One of these genera, *Reticuloppia* Balogh & Mahunka, 1966b, has been transferred (Lee & Birchby 1991a) to Fovoribatulinae (Crassoribatulidae), whilst a number of genera are here grouped in Pseudoppiinae (see following text). This leaves only the following eight genera, of which the majority are cosmopolitan, in the Oribatulinae: *Eporibatula* Sellnick, 1928; *Jornadia* Wallwork & Weems, 1984; *Lucoppia* Berlese, 1908; *Oribatula* Berlese, 1896; *Paraphauloppia* Hammer,

1967; *Phauloppia* Berlese, 1908; *Spinoppia* Higgins & Woolley, 1966; *Zygoribatula* Berlese, 1916.

Other than the South Australian material collected in this study only the cosmopolitan *Zygoribatula* has been recorded from Australia (Hammer 1953). *Paraphauloppia*, previously known only from New Zealand and South America, has been collected in this study (Lee & Birchby 1991b). The current paper includes the first record of the cosmopolitan *Oribatula* from Australia.

Genus *Oribatula* Berlese

Oribatula Berlese, 1896: LXXIX,12. Type-species (original designation): '*Oribatula tibialis*' (=*Notaspis tibialis* Nicolet, 1855; Berlese, 1895: LXXVII,5).
Oribatula: Hammen, 1952: 80.
Oribatula: Travé, 1961: 313.
Oribatula: Coetzer, 1968: 55.

Type-species: *Oribatula tibialis* (Nicolet, 1855)

Diagnosis

Oribatulinae. Twelve, thirteen or fourteen pairs of short, smooth or weakly ciliate hysteronotal setae. Humeral setae (*Z1*, *S1*) similar in shape and size to other hysteronotal setae (rarely *Z1* stouter, but still subequal in length). Proteronotum without translamella, lamella at least lamellate anteriorly (never just costate or lineate), in subparallel pair, medium size or long, distance between lamellar seta *z1* and dorsosejugal furrow greater than 1.5× distance between interlamellar seta *j2* and bothridium of sensory seta *z2*. Genital shield with four pairs of setae.

Distribution

Regarded as possibly cosmopolitan, but all records before this paper appear to be from only the Holarctic or Ethiopian region. Both saxicolous and arboreal on epiphytes (Travé 1961), in Europe found on moss on northern slopes of mountains, and not very sensitive to drought (Hammen 1952), also found in marshes and pasture sod (Krantz 1978). This single record from Australia is from the semi-arid region.

Remarks

Oribatula is very similar to some other oribatulid genera. It only differs from *Zygoribatula* in that it lacks a translamella as commented on later in the 'Remarks' on that genus. It is also very like *Phauloppia*, which differs in having a lineate lamella, seta *z1* closer to *j2* than *j1* and seta *Z1* closer to *S1* than *J2*.

Oribatula caudata Berlese, 1910 from *Citrus deliciosa*, New South Wales, is here combined with *Sellnickia* and is also newly regarded as a synonym of its senior homonym, *Sellnickia caudata* (Michael, 1908). *S. caudata* was originally described from New Zealand, but was redescribed in detail by Grandjean (1958) from the leaves of lemon trees in Queensland. The similarity in appearance, including the presence of a rather long conical posterior process on the hysteronotum of an *Oribatula*-like mite, is considered sufficient to group *Oribatula caudata* in *Sellnickia*.

Oribatula includes the following 15 species and one subspecies (note – many species with 10 pairs of hysteronotal setae were transferred to *Paraphauloppia* by Coetzer, 1968): *O. acuminata* Wallwork, 1964; *O. exsudans* Travé, 1961; *O. florens* Berlese, 1908; *O. incompleta* Mahunka, 1987; *O. interrupta* (Willmann, 1939); *O. interrupta major* (Mihelcic, 1963); *O. pallida* Banks, 1906; *O. pannonica* Willmann, 1949 (see Travé, 1961); *O. parisi* Travé, 1961; *O. sakamorii* Aoki, 1970; *O. saxicola* (Kunst, 1959); *O. tibialis* Nicolet, 1855; *O. torrijosi* Subias, Ruiz & Kahwash, 1990; *O. variabilis* Berlese, 1908; *O. venusta* Berlese, 1908; *O. vera* (Bulanova-Zachvatkina, 1967).

Oribatula runcinata sp. nov.
(Figs 1-3)

Female

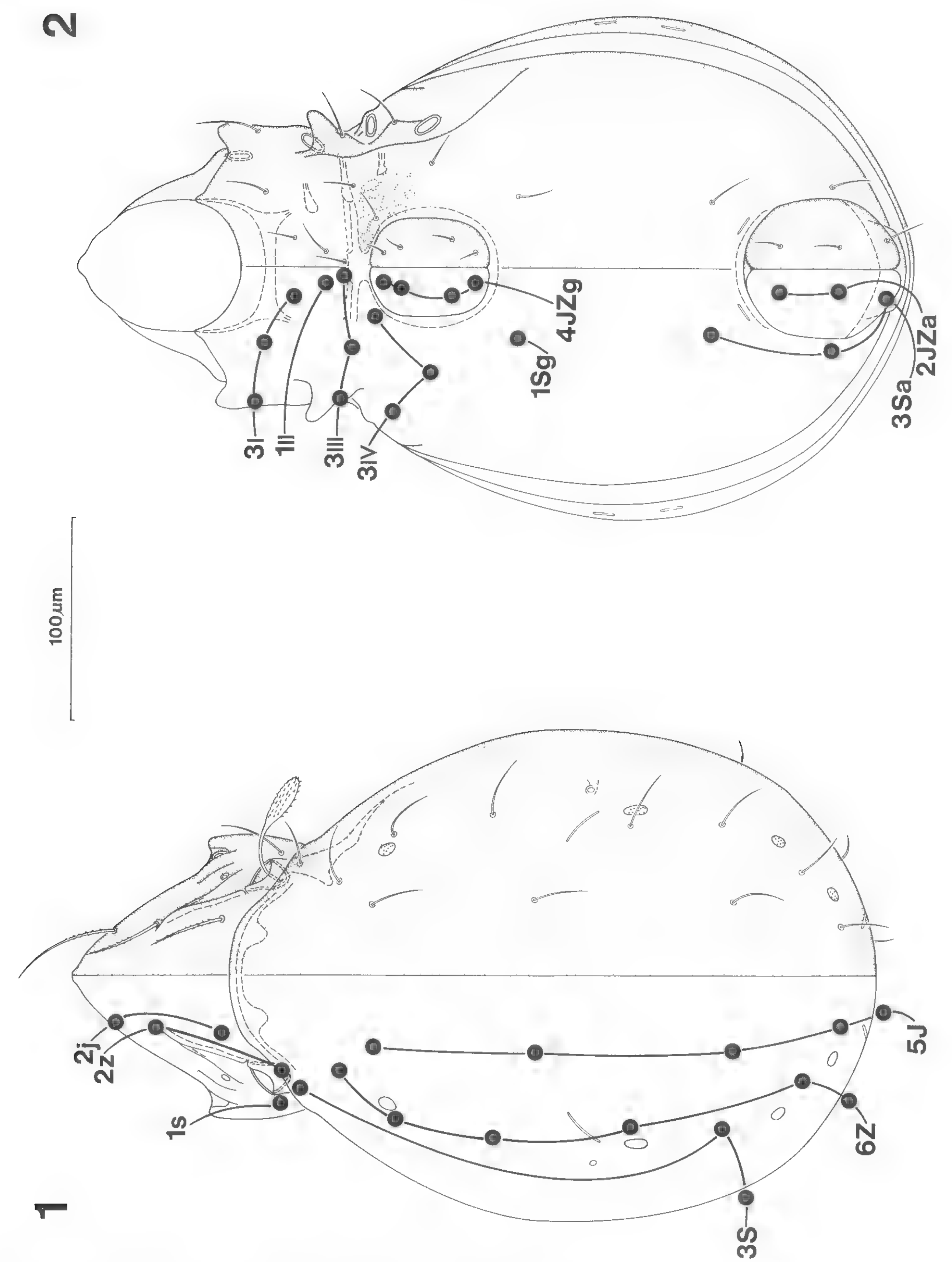
Dorsal profile of hysteronotum ovoid, mid-brown, surface glabrous, without reliculations. Coxite area with faint reticulations. Idiosomal length 397 (n = 15, 357-437). Leg lengths (femur-tarsus for idiosomal length 400): I-222, II-182, III-172, IV-220. Tibial maximum heights (for 400): I-20.5, II-15.5, III-13, IV-14.

Proteronotum with slim lamella, mainly costate, lamellate anteriorly, but not bearing seta *z1* (lies on flat proteronotal surface), and costate sublamella. Setae *j1*, *j2* and *z1* stout, and noticeably ciliate, *j1* longest. Sensory seta (*z2*) clavate, exposed stalk subequal in length to head covered with fine cilia.

Hysteronotal setae short, fine, setose and subequal in length. Multiporose foramina small, *F3* length less than 0.33× distance between setae *Z1*-*Z2*, anterior two pairs (*F3*, *F4*) larger than posterior pairs (*F5*, *F6*), all four pairs round or weakly oval. Slit shaped pore *hf3* sloping outwards towards posterior.

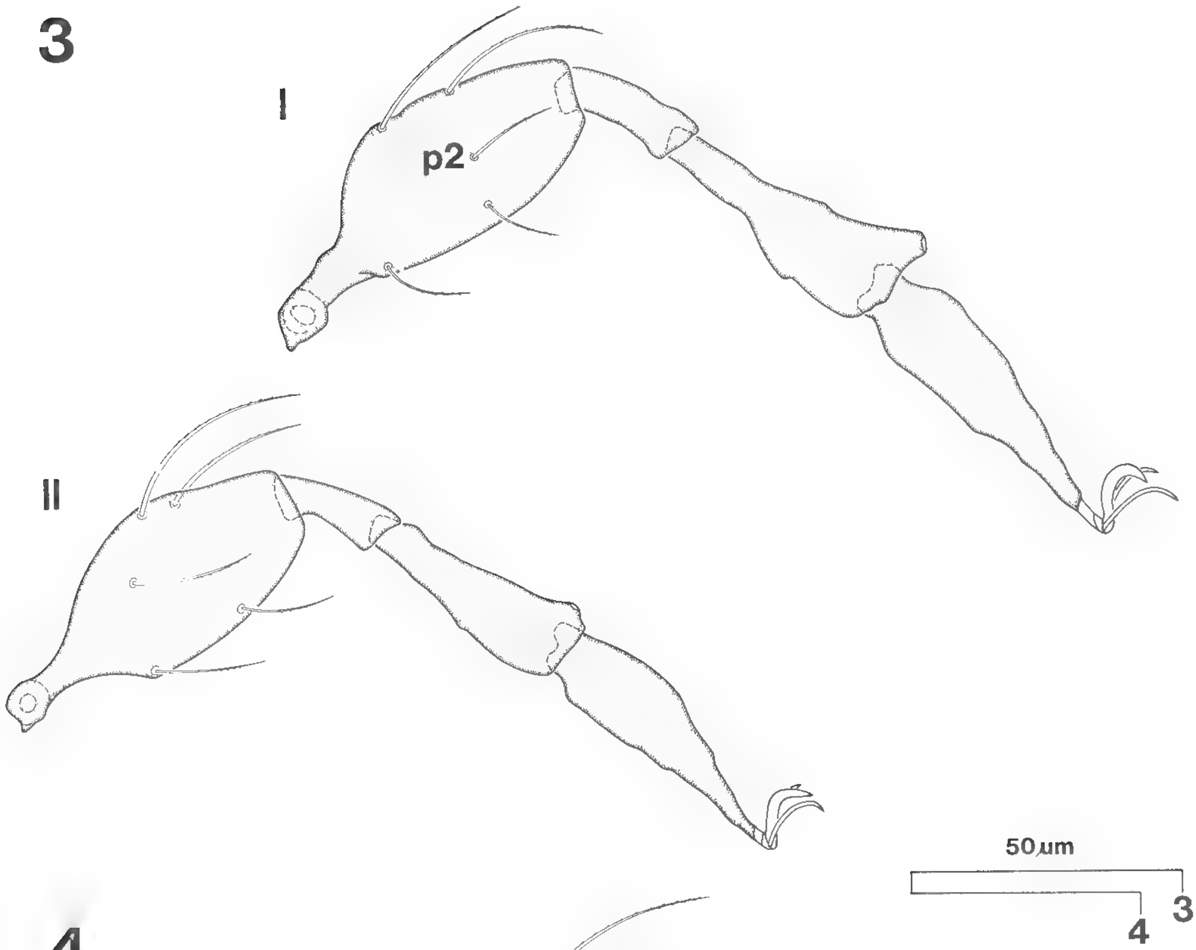
Podosternum with circumpedal ridge merged with rest of subpedal ridge, distinct from and ventral to discidium and pedotectum II, absent below pedotectum I. Discidium forms costate ridge. Setae vary in length, lateral setae (*I3*, *III3*, *IV3*) similar to hysteronotal setae, other coxite setae smaller, smallest setae on genital shields.

Opisthosternum with outer file (*Sa*) of setae longer than coxite setae and setae on anal shield (*JZa*) subequal in length to smallest coxite setae. Slit-like pore *Saf* nearly transverse, more than 45° from longitudinal axis. Eggs subcylindrical with convex ends, 181 × 90 (mean of 7 horizontally aligned eggs, 46% of mean female length), smooth exochorion. Number of eggs



FIGURES 1 AND 2. *Oribatula runcinata,* female soma. 1, notum; 2, idiosternum

3



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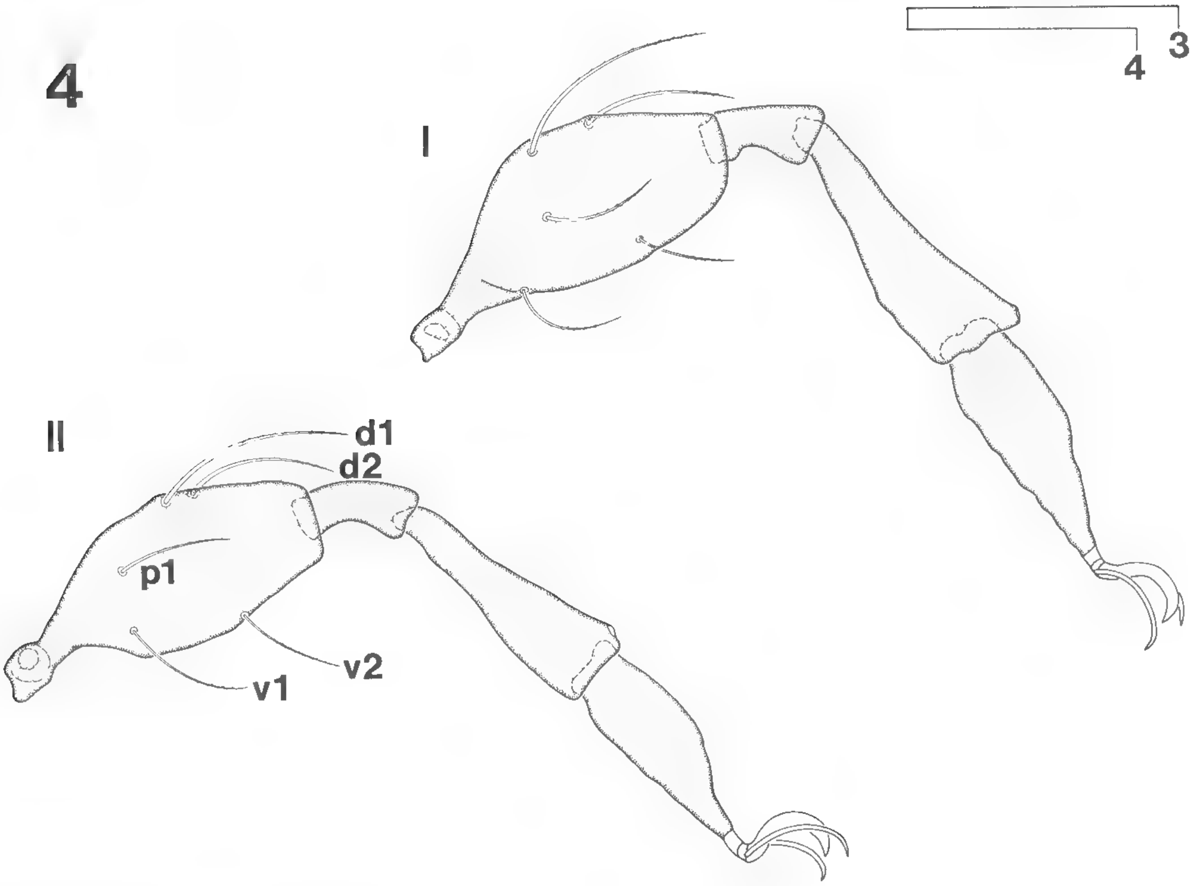


FIGURES 3 AND 4. Right legs I and II, femur-pretarsi, posterior aspect. 3, *Oribatula runcinata;* 4, *Zygoribatula cycloporosa.* All setae on femurs I and II illustrated, *d* = dorsal, *p* = posterior, *v* = ventral.

in female (number of females) as follows: none (2), one (1), two (4), three (5), four (2), six (1).

Legs long (mean femur-tarsus: 50% soma), slim (mean maximum tibial height: 26% of mean length). All femora and trochanters III and IV with dorsal adaxial porose areas and vertical adaxial ridges.

Male

As female except soma smaller, idiosomal length 359 (n = 23, 332-380).

Material examined

Holotype: ♀ (N19901033), soil, litter, moss and other low growth plants under bladder saltbush (*Atriplex vesicaria*) amongst sparse false sandalwood (*Myoporum platycarpum*), Koonamore Vegetation Reserve (32°07′S, 139°21′E), 27.vi.1974.

Paratypes: 11 ♀♀ (N19901034-N19901044); 17 ♂♂ (N19901045-N19901061); 1 ♀, 2 ♂♂ BMNH; 1 ♀, 2 ♂♂ FMNH; 1 ♀, 2 ♂♂ NZAC; same data as holotype.

Distribution

Australia (Aa), South Australia. Semi-arid low shrubland (Koonamore Vegetation Reserve), Lake Eyre Basin, 15 ♀♀, 23♂♂/ 5 of 8 × 25 cm^2.

Remarks

The specific name *runcinata* is derived from the Latin 'runcinare' to 'smooth' and refers to the unsculptured notal surface. The slim lamellae distinguish *O. runcinata* from other species of *Oribatula*, and although *O. pannonica* Willmann, 1949 also has slim lamellae they are extensive enough to carry seta *z*1. The large sensory seta (*z*2) also distinguishes it, *O. vera* (Bulanova-Zachvatkina, 1967) having the next largest seta *z*2.

Genus *Zygoribatula* Berlese

Zygoribatula Berlese, 1916: 317. Type-species (original designation): '*Oribates connexus* Berl.'.
Neoribatula Ewing, 1917: 128.
Zygoribatula: Travé, 1961: 328.
Zygoribatula: Coetzer, 1968: 92.

Type-species: *Zygoribatula connexa* (Berlese, 1904)

Diagnosis

Oribatulinae. Thirteen or fourteen pairs of short to medium, smooth or weakly ciliate hysteronotal setae. Humeral setae (*Z*1, *S*1) similar in shape and size to other hysteronotal setae (rarely *Z*1 stouter and more ciliate, but still subequal in length or smaller). Proteronotum with lamellate translamella and lamella, subparallel pair of lamellae, medium size to long, distance between lamellar seta (*z*1) and dorsosejugal furrow greater than 1.5× distance between interlamellar seta *j*2 and bothridium of sensory seta *z*2. Genital shield with four pairs of setae.

Distribution

Cosmopolitan. Both saxicolous and arboreal, in moss, or on sap or bark, also hemiedaphic in many different types of soil from sand to clay, with or without humus and even in the intertidal zone. Three species are now known from Australia. *Zygoribatula longiporosa* Hammer, 1953 was recorded from pasture in southern Queensland, *Z. magna* Ramsay, 1966, originally described from pasture near Wellington, New Zealand, is now recorded from pasture near Adelaide, South Australia, and *Z. cycloporosa* sp. nov. was collected at the Mallee-heath site under *Banksia* shrubs.

Remarks

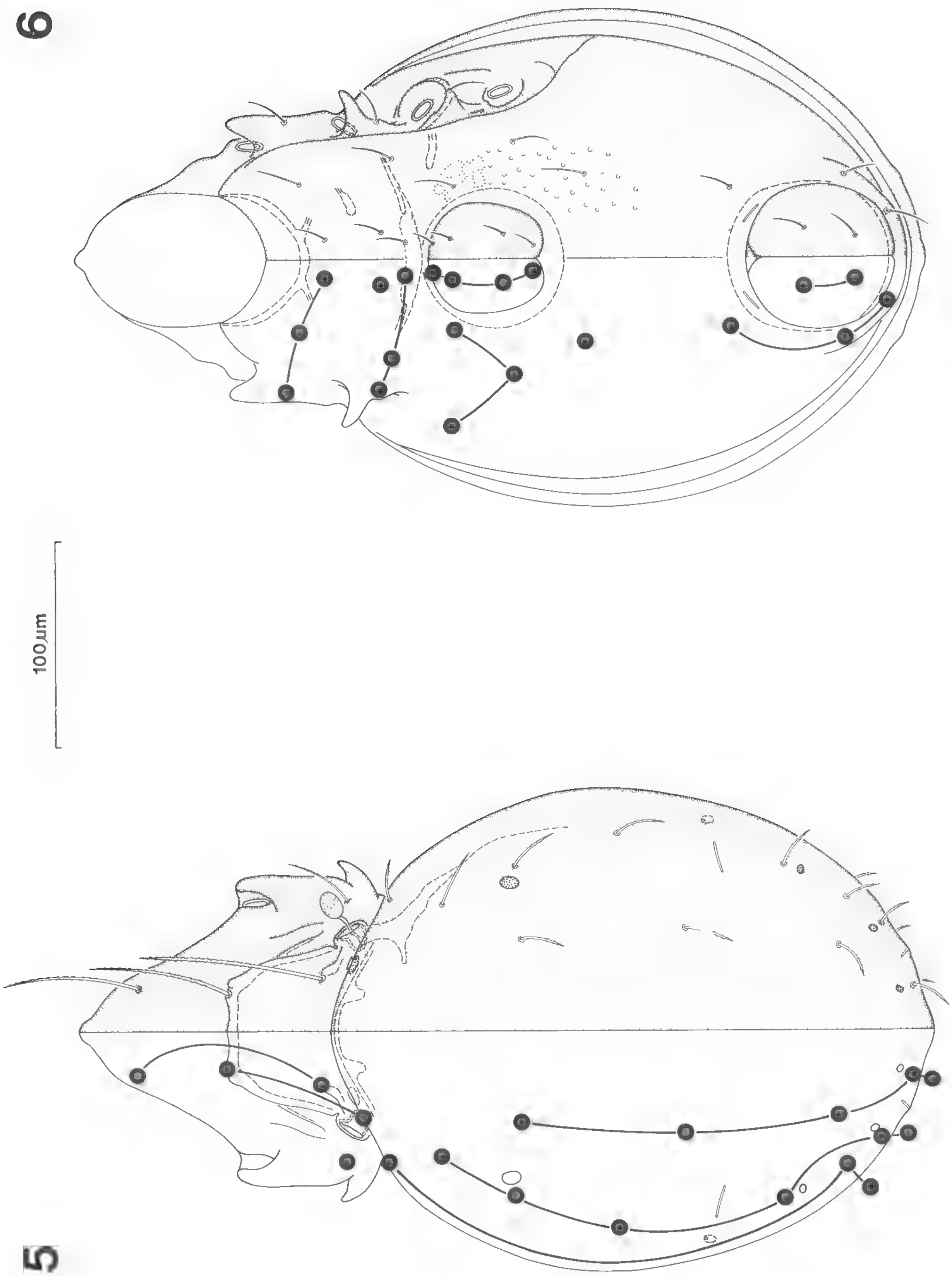
Zygoribatula is very similar to *Oribatula*, as discussed by Travé (1961), who decided to retain the genus 'pour des raisons de commodité', implying that it may not be valid. The only character distinguishing *Zygoribatula* from *Oribatula* is the presence of a complete lamellate translamella between setae *z*1-*z*1 and this may be discontinuous in some specimens of a species (Luxton, 1987). *Zygoribatula* is much more species-rich than *Oribatula*. Fritz (1982) lists 85 species, but two of these (*Z. interrupta* and *Z. saxicola*) are here grouped in *Oribatula* as by Travé (1961). *Zygoribatula lenticulata* Minguez & Subias, 1986, because of its similarity to *Romanobates* in the Crassoribatulidae, had the chaetotaxy of two of its male paratypes examined and for femur I it was 1,2/2,1 and for femur II it was 1,2/2,1, as for all oribatulids, and not fewer setae as for Crassoribatulidae. *Zygoribatula dactilaris* Subias, Ruiz & Kahwash, 1990 is newly combined with *Phauloppiella*, as commented on in the following remarks on Pseudoppiinae. A further three species are included in *Zygoribatula* as follows: *Z. baloghi* Mahunka, 1986, *Z. endroedyi* Mahunka, 1986 and *Z. knighti* Luxton, 1987.

Zygoribatula cycloporosa sp. nov.
(Figs 4-6)

Female

Dorsal profile of hysteronotum ovoid, light-brown, surface sparsely punctate. Coxite area with reticulations. Idiosomal length 401 (n = 3, 388-409). Leg lengths (femur-tarsus for idiosomal length 388): I-244, II-208, III-203, IV-249. Tibial maximum heights (for 388): I-23, II-18, III- 18, IV-18.

Proteronotum with lamellate lamella and translamella, and costate sublamella and costate ridge between setae *j*2-*z*2. Setae *j*1, *j*2 and *z*1 long, stout, and



FIGURES 5 AND 6. *Zygoribatula cycloporosa*, female soma. 5, notum; 6, idiosternum. For setal notation see Figs 1 and 2.

noticeably ciliate, *j*2 longest. Sensory seta (*z*2) medium size (length 0.33 × distance between setae *z*1-*z*2), capitate, exposed stalk subequal in length to head covered with fine cilia.

Hysteronotal setae short, stout, setose (weakly ciliate) and subequal in length. Multiporose foramina small, diameter of *F*3 less than 0.33 × distance between setae *Z*1-*Z*2, anterior pair (*F*3) conspicuously larger than posterior pairs (*F*4, *F*5, *F*6), all four pairs round. On right side of one female, foramina *F*5 and *F*6 replaced by single pair in intermediate position. Slit shaped pore *hf*3 nearly transverse, sloping acutely inwards towards posterior.

Podosternum with circumpedal ridge merged with rest of subpedal ridge, distinct from and ventral to discidium and pedotectum, present (may be faint) below pedotectum I. Discidium forms semicircular costate ridge around posterior margin of acetabulum for leg III. Setae slim, setose, longer if positioned closer to lateral margin. Smallest setae on genital shields. On right side of one female, five genital setae.

Opisthosternum with setae in outer (*Sa*) and inner (*JZa*) files subequal in length. Slit-like pore *Saf* nearly transverse, more than 45° from longitudinal axis. Eggs subcylindrical with convex ends, 168 × 74 (mean of 4 horizontally aligned eggs, 42% of mean somal length), smooth exochorion. Number of eggs in female (number of females) as follows: one (1), two (1), four (1).

Legs long (mean femur-tarsus: 57% soma), slim (mean maximum tibial height: 30% of mean length). All femora and trochanters III and IV with dorsal adaxial porose areas and, on femora III and IV, strong vertical ridges on adaxial surface, ventral to porose areas.

Male

Unknown.

Material examined

Holotype: ♀ (N19901280), sand, litter, under banksia shrubs (*Banksia ornata*) amongst other sclerophyllous shrubs and sparse brown stringybark mallee (*Eucalyptus baxteri*), Tamboore Homestead (35°57′S, 140°29′E), 4.viii.1974.

Paratypes: 2 ♀♀ (N19901281, N19901282) same data as holotype.

Distribution

Australia (Aa), South Australia. Mallee-heath, tall open shrubland (Tamboore Homestead, near Mt Rescue Conservation Park), Murray-Darling basin, 3 ♀♀/ 1 of 8 × 25 cm^2.

Remarks

The prefix of the specific name *cycloporosa* is derived from the Greek 'kyklos' for 'circle' and refers to the hysteronotal multiporose foramina, which are circular in outline. The only other species which have small, circular hysteronotal foramina and mainly costate lamellae and translamella (with limited lamellate parts and no distinct cuspis at apex of lamella) are *Z. frisiae* (Oudemans, 1900) from Netherlands, *Z. knighti* Luxton, 1987 from England and *Z. tenuelamellata* Miheleie, 1956 from Spain. *O. cycloporosa* is regarded as the most similar to *Z. knighti* because of the presence of a costate ridge between setae *j*2 and *z*2. It differs from all three species in having long interlamellar setae (*j*2) and an almost globular caput on setae *z*2.

Zygoribatula longiporosa Hammer
(No figures)

Zygoribatula longiporosa Hammer, 1953: 236.

Female

Legs: Chaetotaxy of femur I 0,2/2,1; femur II 0,2/2,1.

Material examined

Syntypes, two females (W1854, W3569), pastures, lot 52-56 29, Yeerongpilly, Queensland, 14th May, 1952, F. H. S. Roberts.

Remarks

Zygoribatula longiporosa is the only species of Oribatulidae (as delineated here) recorded from Australia previous to this study. It was collected in large numbers from calf pastures in Queensland and examined for cysticercoids of the tapeworm *Moniezia benedeni*, between 1.8% and 5.7% being infested depending on the pasture sampled (Roberts, 1953). The types have been examined to establish the leg chaetotaxy, which has proved to be as found in the Oribatulidae and not reduced by at least the absence of a ventral seta on femur II as for the Fovoribatulinae. Proposals have been made that *Z. longiporosa* and *Z. tadrosi* Popp, 1960 from Egypt are synonymous with *Z. undulata* Berlese, 1916 from Italy (Pérez-Iñigo, 1974) and that *Z. longiporosa* is synonymous with *Z. heteroporosa* Wallwork, 1972 from California (Bhattacharya & Banerjee, 1980). These proposed synonymies are not accepted. The similarities between these species are the elongate first hysteronotal foramina (*F*3) and the narrow lamella without a cuspis. On the other hand, even on the basis of the published descriptions, there are enough differences between the species (*e.g.* the size and shape of other hysteronotal foramina and the relative sizes of proteronotal setae) to suggest that they are valid taxa.

Zygoribatula magna Ramsay, 1966
(No figures)

Female

Dorsal profile of hysteronotum ovoid, dark-brown

colour, surface covered with fine striations. Lateral punctations and areolae with strong reticulations in coxite area. Idiosomal length 507 (n = 25, 468-535). Leg lengths (femur-tarsus for idiosomal length 516): I-266, II-245, III-242, IV-307. Tibial maximum heights (for 516): I-26, II-19, III-17, IV-19. Legs long (mean femur-tarsus: 51% soma), slim (mean maximum tibial height: 28% of mean length). Chaetotaxy of femur I 0,2/2,1; femur II 0,2/2,1. Dorsal adaxial porose areas and reticulate abaxial sculpturing on all femora and trochanters III and IV, strong vertical ridges on adaxial surface, ventral to porose areas on femora III and IV. Eggs subcylindrical with convex ends, 177 × 93 (mean of 4 horizontal aligned eggs, 35% of mean somal length), smooth exochorion. Number of eggs in female (number of females, total 25) as follows: none (23), two (1), three (1).

Male

As for female except soma smaller, idiosomal length 490 (n × 25, 463-516).

Material examined

Undesignated: 116 ♀♀ (N19901062-N19901177); 102 ♂♂ (N19901178-N19901279); 5 ♀♀, 5 ♂♂ BMNH; 5 ♀♀, 5♂♂ FMNH; 5 ♀♀, 5 ♂♂ NZAC; soil, bases of cultivated grass and plantain (*Plantago lanceolata*) in pasture of sheep, Glenthorne Research Station, O'Halloran Hill (35°02′S, 138°32′E), 12.vi.1974.

Distribution

Australia (Aa), South Australia. Cultivated pasture (Glenthorne Research Station), Southern Gulfs, 131 ♀♀, 117 ♂♂/ 6 of 8 x 25 cm^2.

Remarks

Zygoribatula magna was first described from pastures near Wellington, New Zealand, where they were collected in samples with *Setobates scheloribatoides* (Ramsay, 1966) and 2-6% of the combined population of the two species were infested with tapeworm cysticercoids. No cysticercoids were found in the South Australian specimens.

Subfamily PSEUDOPPIINAE Mahunka

Pseudoppiinae Mahunka, 1975: 293
Constrictobatinae Balogh & Balogh, 1984: 280

Nominotype: *Pseudoppia* Mahunka, 1975

Diagnosis

Oribatulidae. Ventrosejugal apodemes do not meet across midsternal line. Hysteronotum pear-shaped with no humeral process, and between 10-15 pairs of setae, sejugal furrow extending anterior to bothridium (around seta *z*2), usually evanescent or absent across mid-line. Two, three or four pairs of multiporose hysteronotal foramina present. Genital shield usually with two or three pairs of setae (exceptions with 4*JZg*: *Phauloppiella* and *Ausoribula*). Legs medium length and stout.

Remarks

The Pseudoppiinae Mahunka, 1975 was established with three genera. Balogh & Balogh (1984), in their comprehensive classification of the Oripodoidea (as Oribatuloidea), ignored Pseudoppiinae, leaving two of the included genera in Oribatulinae, and mistakenly omitting altogether the third original genus, *Symphauloppia* Balogh, 1972. Lee (1987) once again recognised the Pseudoppiinae and included a further two genera, *Constrictobates* from Fenicheliidae and *Phauloppiella* from Oribatulinae. Later, Lee (1991) transferred a further five genera from either Capilloppiinae or Oribatulinae to Pseudoppiinae so that all the oribatulid genera with a gap between the ventrosejugal apodemes are included. One of these five genera, *Lunoribatula* Mahunka, 1982, has a reduced chaetotaxy on femora I and II as pointed out in previous remarks on Oribatulidae, and is now grouped in the Crassoribatulinae.

Attention is drawn here to the Liebstadiinae Balogh & Balogh, 1984, which are similar to the Pseudoppiinae, but are not regarded as allied to them, although this may change in future classifications of the Oripodoidea. The subfamily was established within the Protoribatidae, a family with multiporose foramina, a single pretarsal claw and usually with pteromorphs which are sometimes represented by only small humeral processes (as in Liebstadiinae), which is considered as representing a secondary loss of pteromorphs (Lee 1991). On the other hand, *Liebstadia* Oudemans 1906 was included in Scheloribatidae by Grandjean (1954) and still is by some acarologists (Wunderle, Beck & Woas 1990), supporting a phylogenetic model that it is primitive within the Scheloribatidae, most genera of which have sacculate hysteronotal foramina. Although the relationship of the Liebstadiinae to the Pseudoppiinae is uncertain, the adults of known taxa can easily be distinguished by the number of pretarsal claws.

The following nine genera are regarded as belonging to the cosmopolitan Pseudoppiinae: *Ausoribula* gen. nov., *Constrictobates* Balogh & Mahunka, 1966; *Diphauloppia* Balogh & Balogh, 1984; *Gerloubia* Coetzer, 1968; *Phauloppiella* Subias, 1977; *Pseudoppia* Pérez-Iñigo, 1966; *Senoribula* Mahunka, 1975; *Subphauloppia* Hammer, 1967; *Symphauloppia* Balogh, 1972. The only previous Australian records of the Pseudoppiinae have been of *Constrictobates*, originally from Western Australia and more recently from South Australia (Lee 1987). *Ausoribula*, established here, is also from South Australia.

Genus *Ausoribula* gen. nov.

Type-species: *Ausoribula quagesetosa* sp. nov.

Diagnosis

Pseudoppiinae. Hysteronotum with 11 pairs of setae (*J5*, *J6*, *Z1*-*Z6*, *S1*, *S5*, *S6*) and three pairs of foramina (*F3*, *F4*, *F5*). Dorsosejugal furrow not continuous across mid-dorsal line. Lamella present, mainly costate, only lineate in region of seta *z1*. Three prosternal apodeme bases (*I*, *II* and sejugal) present. Four pairs of setae on genital shields (4*JZg*) and two pairs of setae on anal shields (2*JZa*). Legs medium length or short (order of decreasing length: I, IV, II, III), tarsi I-III about twice genu length, tarsus IV about 3× genu length.

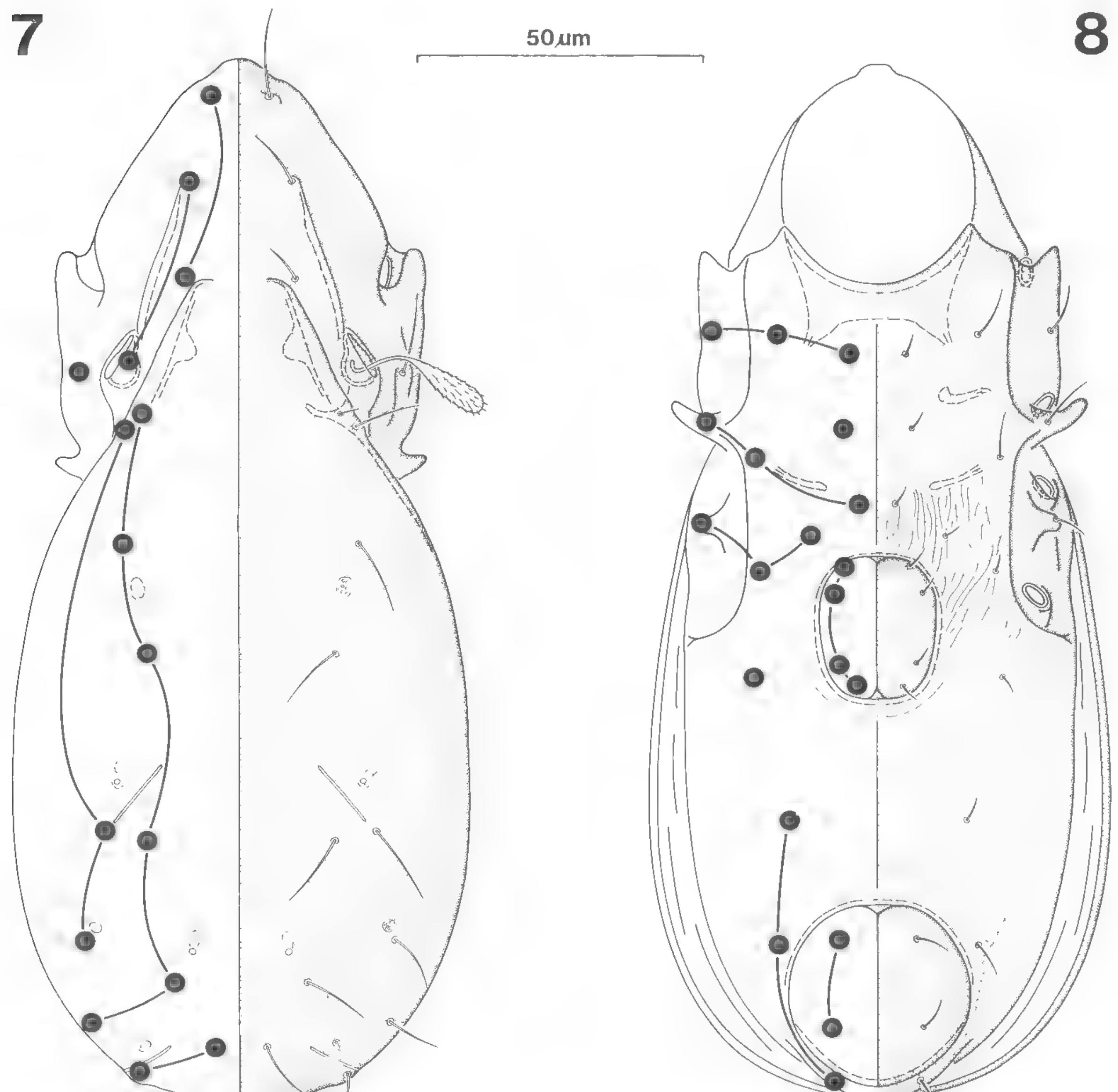
Distribution

Single species known only from South Australia.

Remarks

The prefix of *Ausoribula* refers to the genus being only known from Australia, while the rest of the name is a derivation from Oribatei (= Cryptostigmata), which Michael (1884) suggested may be derived either from the Greek words 'oros' (a mountain) and 'baino' (I go or walk) or from the proper noun 'Oribasus', Acteon's dog.

The relationships of *Ausoribula* within the Pseudoppiinae are uncertain. The recognition of pseudoppiine genera depends heavily on somal chaetotaxy, and *Ausoribula* has 14 pairs of hysteronotal setae like *Senoribula* and 4 pairs of genital setae like *Phauloppiella*. On the other hand, the presence of lamellae and only three pairs of hysteronotal foramina



FIGURES 7 AND 8. *Ausoribula quagesetosa*, female soma. 7, notum; 8, idiosternum. For setal notation see Figs 1 and 2.

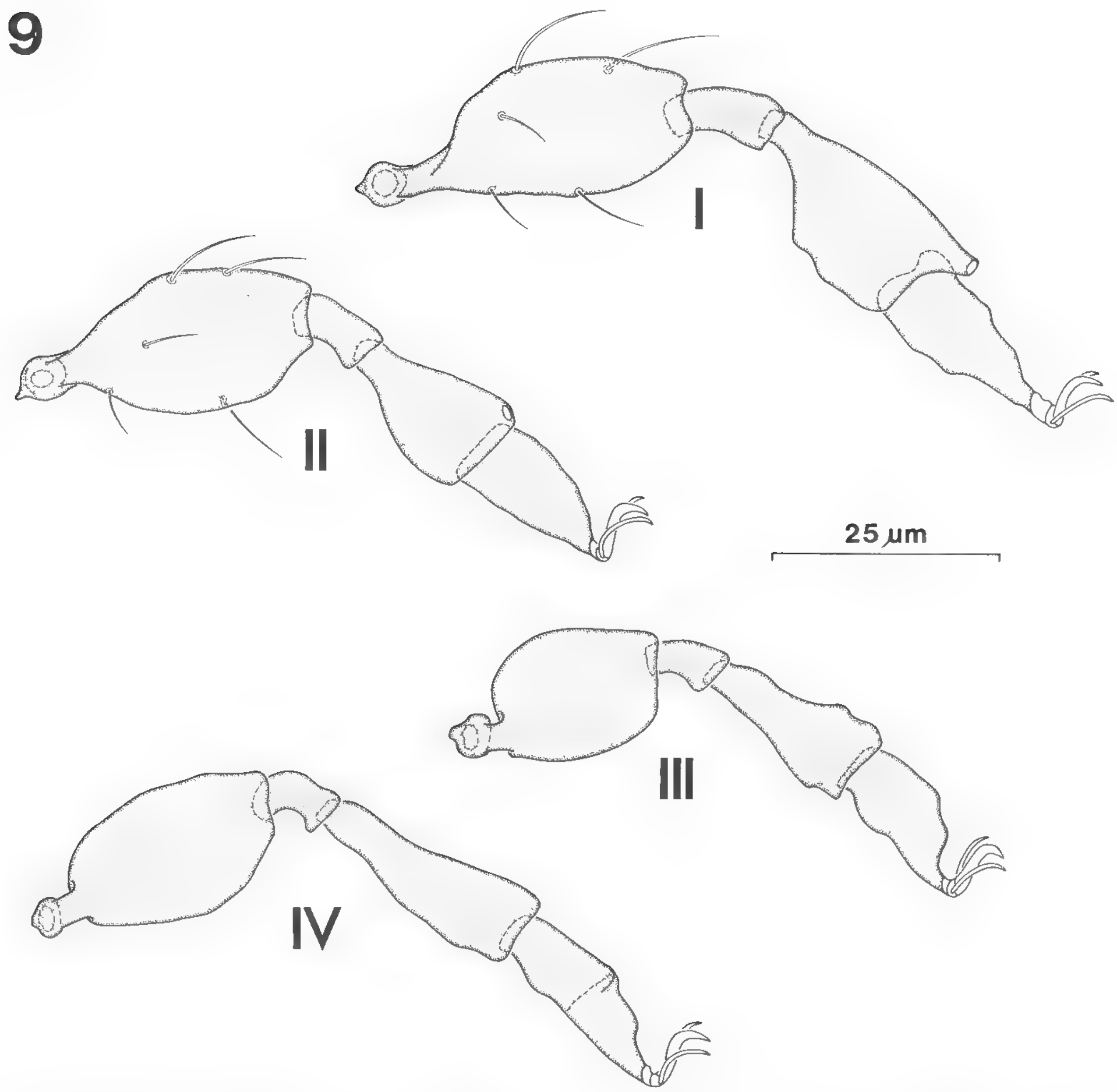


FIGURE 9. *Ausoribula quagesetosa*, female right legs I-IV, femur-pretarsi, posterior aspect. All setae on femurs I and II illustrated, *d* = dorsal, *p* = posterior, *v* = ventral.

are character states shared with the other Australian genus, *Constrictobates*, and may indicate that these two genera are closely allied.

Ausoribula quagesetosa sp. nov.
(Figs 7-9)

Female

Dorsal profile of hysteronotum nearly parallel sided, straw-colour, surface smooth. Coxite area with fine striations. Idiosomal length 183 (n = 8, 177-191). Leg lengths (femur-tarsus for idiosomal length 182): I-95, II-77, III-68, IV-85. Tibial maximum heights (for 182): I-13, II-11.5, III-10, IV-10.

Proteronotum indented posteriorly by forward protrusion of hysteronotum. Weakly lamellate lamella; sublamella, prelamella and translamella absent. Setae *j2* and *z1* shorter than all other notal setae except hysteronotal seta *Z1*. Sensory seta (*z2*) clavate, exposed stalk shorter than head, covered with fine cilia.

Hysteronotal seta mainly medium size, fine, setose and subequal in length, except for short seta *Z1*. Only three pairs of small, faint hysteronotal foramina. Unnamed pair of sacculate pores between setae *Z5* and midline. Long slit shaped pore *hf3* sloping outwards towards posterior.

Podosternum with circumpedal and sub-pedal ridge running close to base of legs, divided into two separate parts at pedotectum II. Discidium forms slim tubercle. Setae vary in length, with *I2*, *I3*, *II3* longest and *IV1* and *IV2* shortest, similar to genital setae.

Opisthosternum with medium length setae compared to range in size of coxite setae. Slit-like pore *Saf* not located, although indistinct groove near genital orifice margin level with seta *Sa* may represent remnant. No eggs observed.

Legs medium length (mean femur-tarsus: 45% soma), stout (mean maximum tibial height: 51% of mean length). No dorsal porose areas, reticulate abaxial or ridged adaxial sculpturing on femora and trochanters, except that femur IV has strong vertical ridges on adaxial surface. Tarsus IV long (3× length of genu) with a vertical ridge halfway along its abaxial surface.

Male

As for female except soma smaller, idiosomal length 173 (n = 12, 167-177).

Material examined

Holotype: ♀ (N19901283), sand, litter, under banksia shrubs (*Banksia ornata*) amongst other sclerophyllous shrubs and sparse brown stringybark mallee (*Eucalyptus baxteri*), Tamboore Homestead (35°57′S, 140°29′E), 4.viii.1974.

Paratypes: 7 ♀♀ (N19901284-N19901290), 12 ♂♂ (N19901291-N19901302) same data as holotype.

Distribution

Australia (Aa), South Australia. Mallee-heath, tall open shrubland (Tamboore Homestead, near Mt Rescue Conservation Park), Murray-Darling basin, 7 ♀♀, 12 ♂♂/ 3 of 8 x 25 cm^2.

Remarks

The prefix of the specific name *quagesetosa* is derived from abbreviations of the Latin 'quattuor' for 'four' and 'genitus' for 'be born' and refers to the four pairs of genital setae. It is the only species in the genus.

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CTENOPHURUS TJANTJALKA, A NEW DRAGON LIZARD (LACERTILIA: AGAMIDAE) FROM NORTHERN SOUTH AUSTRALIA

G. R. JOHNSTON

Summary

A new species of agamid lizard, Ctenophorus tjantjalka, is described and illustrated. It is saxicolous in habit, appears to be confined to northern South Australia and is a member of the C. decresii species group. It may be distinguished from all other members of this group by its deep head and short snout, wrinkled snout scales, the presence of a vertebral keel, dorsal colouration of males and females and the lack of banding on the tail.

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JOHNSTON, G. R. 1992. *Ctenophorus tjantjalka*, a new dragon lizard (Lacertilia: Agamidae) from northern South Australia. *Rec. S. Aust. Mus.* **26**(1): 51–59.

A new species of agamid lizard, *Ctenophorus tjantjalka*, is described and illustrated. It is saxicolous in habit, appears to be confined to northern South Australia and is a member of the *C. decresii* species group. It may be distinguished from all other members of this group by its deep head and short snout, wrinkled snout scales, the presence of a vertebral keel, dorsal colouration of males and females and the lack of banding on the tail.

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Members of the *Ctenophorus decresii* species group represent a distinct saxicolous ecomorph within the extensive Australian radiation of agamid lizards. This group has been diagnosed by Houston (1974) and extended by Storr (1981). The species described herein as new, is a member of the *C. decresii* species group and inhabits the barren, rocky ranges of far northern South Australia.

Specimens of this taxon have been received at the South Australian Museum since 1960 but were variously misidentified, most of them as either *C. rufescens* or *C. vadnappa*. Warburg's (1966) reference to *C. fionni* at Wintinna in northern South Australia was probably based on this species. White's (1979) records of *C. vadnappa* from the Mabel Range near Oodnadatta are also based on this species. Houston (1978) regarded several specimens of this new species as *C. rufescens*, thereby incorrectly extending that species' distribution east of the Stuart Highway.

Materials And Methods

Eighteen morphometric measurements and eight meristic counts were made of all available specimens of the new taxon (N = 17) and *C. rufescens* (N = 89), and a selection of *C. vadnappa* (N = 42) in the South Australian Museum (SAM) and Western Australian Museum (WAM). Morphometric measurements were snout-vent length (SVL), the distance between the tip of the snout and the anterior margin of the eye (SL), eye diameter (EYE), the horizontal distance from the posterior margin of the eye to the angle of the jaw (POCL), head depth immediately behind the eye (HD), width between the nostrils (SWD), width between the tympani (HWD), length of the upper arm (HUML), length of lower arm (FAL), length of the hand (ML), length of the thigh (FEML), length of tibia (TIBL), length of foot (PL), distance from axilla to groin (AG), tail length (TL), head length (HL = SL+EYE+POCL), forelimb length (FLL = HUML+FAL+ML) and hindlimb length (HLL = FEML+TIBL+PL). Meristic counts were the number of scales between the rostral and the nasal (PRENAS), number of scales between the nasal and the supralabials (SUBNAS), number of scales between the nasals across the top of the snout (INTERNAS), number of supralabials (SUPLAB), number of infralabials (INLAB), number of subdigital lamellae on the fourth finger (SD4F), number of subdigital lamellae on fourth toe (SD4T) and the number of femoral and preanal pores (FEMPREPO).

Descriptive statistics were calculated for a number of meristic characteristics (Table 1) from samples of *C. rufescens, C. vadnappa* and the new taxon. Multiple comparisons of these variables were made using single classification ANOVA (Sokal & Rohlf 1981). Multiple discriminant function analyses (Reyment *et al.* 1984) of raw measurements and meristic characteristics were done using SPSS PC+ (Norusis 1986) on a Pantek PC-16 personal computer. Sexes were pooled for all analyses.

Ontogenetic variation was examined by fitting HL, HD, HWD, FLL, FEML, ML, HLL, TL and SVL for *C. rufescens, C. vadnappa* and the new taxon to the logarithmic form of the allometric equation $Y = bSVL^a$ (Huxley 1932; Gould 1966), where Y is the variable being examined, SVL is used as a measure of overall size, a is the allometric coefficient (slope) and b is the y-intercept. Allometric coefficients were tested against unity using standard normal deviates (Zar 1974).

Ctenophorus tjantjalka sp. nov.
Figs 1-3, 5B

Types

Holotype: SAM R17934a just N Mabel Range, S.

Aust., 26°45′S, 113°48′E, South Australian Herpetology Group, 18-20.*iv*.1979, male.

Paratypes: SAM R4328 Mt Chandler, S. Aust. (27°00′S, 113°19′E), H. Wopfner, 20.*x*.1960; SAM R6227 80 miles W Oodnadatta, Copper Hill Station (27°57′S, 134°19′E), H. Frahn, 19.*vii*.1965; SAM R12495 20 miles S Hawks Nest Well, S. Aust. (27°45′S, 134°07′E), J. Bredl, 1971; SAM R15608 Rocky Gully, SW old Peake HS, S. Aust. (28°05′S, 135°54′E), Rostrevor College, *ix*.1976; SAM R15936a-d near Peake Ruins, S. Aust. (28°05′S, 135°54′E), T. F. Houston, 18-19.*iv*.1977 (SAM R15936a is a dried skeleton); SAM R17701 Hawks Nest Well, S. Aust. (27°30′S, 134°13′E), B. Miller and M. Galliford, 26.*iii*.1979; SAM R17934b, SAM R17935 just N Mabel Range, S. Aust. (26°45′S, 135°48′E), South Australian Herpetology Group, 18-20.*iv*.1979; SAM R20579-80 Copper Hill Station, 19km E Mt Willoughby, S. Aust. (27°57′S, 134°19′E), D. J. Morafka, 12.*iv*.1979; SAM R36731-33 Davenport Range, S. Aust. (28°27′S, 136°02′E), M. Adams and T. Reardon; SAM R37115 83km N Coober Pedy, S. Aust. (28°27′S, 134°12′E), J. Cornish, 15.*x*.1990.

Diagnosis

A member of the *Ctenophorus decresii* group (*sensu* Houston 1974 and 1978, *cf.* Storr, Smith & Johnstone 1983). Distinguishable from all other members of this group in the following combination of characters: snout scales wrinkled; vertebral keel line present, at least anteriorly; flanks with pale cream to pale salmon pink patches on a grey-brown background in adult males; large pale grey to white spots present on dorsum in females and juveniles; tail without broad alternate dark and pale bands.

Description

A robust, moderate-sized dragon lizard reaching a SVL of 73 mm and a total length of 208 mm; head relatively short and deep; snout moderately obtuse, rising fairly steeply in profile; nostril below a sharp canthus rostralis; body moderately depressed; forelimbs relatively large, reaching or almost reaching groin when adpressed; hindlimbs quite long, 94-122 percent of SVL; tail long and evenly tapering. In juveniles the head and appendages are relatively longer than in adults (Table 2).

Scales on top of snout coarsely wrinkled in adults, tending to simple keeled in juveniles; a row of enlarged, longitudinally-ridged or carinate scales from nostril below eye to above ear; outer margins of eyelids fringed with a row of acute scales; 5-7 scale rows separating

FIGURE 1. Adult male *Ctenophorus tjantjalka* (SAM R36731) from the Davenport Range, South Australia. SVL = 65mm.

FIGURE 2. Adult female *Ctenophorus tjantjalka* (SAM R37115) from 83km N Coober Pedy, South Australia. SVL 47mm.

nasals from supralabials; 13-17 supralabial scales on each side; temporal, occipital, nuchal and axillary scales generally very small and convex; folds of skin above and behind ear opening on sides of neck with clusters of small spines, feebly developed in juveniles; low nuchal crest present; a row of perfectly aligned, keeled scales extends dorsally from the nuchal crest to the base of tail along the midline in males, may be feebly developed in females and juveniles; this keel line frequently accentuated by being raised on a fold of skin; scales on flanks small, subtubercular and homogeneous, grading into slightly larger, flatter dorsal body scales which are feebly keeled in adults to smooth in some juveniles; flanks without scattered individual tubercles; ventral scales homogeneous, smooth, substantially larger than dorsal scales and much larger than lateral scales; scales on tail and dorsal surfaces of limbs large and strongly keeled; 33-46 femoral and preanal pores regularly spaced, with 1-4 scales between pores, along a more or less straight line extending the full length of thighs, but interrupted medially; each pore surrounded by several scales, those anterior to it being slightly enlarged.

Adult males (Fig. 1) vary from dark, chocolate brown to grey dorsally, with dark grey to black reticulations which tend to form an irregular dorsolateral stripe. Paler reticulations tend to form transverse bars on flanks which interrupt dark dorsolateral stripes; these pale bars are pale cream dorsally, grading to pale salmon pink laterally. Vertebral region brown to grey, peppered with black and cream, as are the tail and limbs; tail may have irregular darker and lighter bands distally. Chest and ventral surface of forelimbs dark grey to black, tapering toward the midline caudally. Gular fold and clusters of spines on nape pale cream. Bars of grey to brown and cream radiate from the eye to the brow, and from the eye over the upper lip, and along the lower lip. Throat cream with fine, dark grey reticulations, tending to form 2-3 irregular stripes on jowls. Scapular fold black with cream edge.

Adult females (Fig. 2) brick-red to brown dorsally; cream ventrally. Irregular black transverse bars on flanks, interspersed with thinner irregular pale grey white bars. Vertebral region with irregular black and pale grey spots which may align and be continuous with lateral bars. Dorsal surfaces of limbs peppered with pale grey scales and irregular, small, black markings. Throat and chest lightly peppered with dark grey to black, becoming heavier on jowls where it tends to form 2-3 irregular stripes. Clusters of spines on nuchal region pale grey to white.

Juveniles are very similar to the females in colour and pattern; the pattern may be finer than in adults. Specimens which have been in alcohol for some time fade considerably so that the dorsum becomes pale brown and any pattern barely visible.

Measurements of Holotype (in mm)

Snout-vent length, 73.0; head length, 15.5; head width, 15.2; fore limb length, 33.3; hind limb length, 78.1; tail length, 135.

Etymology

The specific epithet is the name used by the Aboriginal people of north-western South Australia for saxicolous agamid lizards. It is used as a noun and is not subject to termination changes.

Distribution and Habitat

Widespread in the interior of South Australia, between the Indulkana Range and Oodnadatta in the north and Coober Pedy and the Davenport Range in the south (Fig. 3).

All specimens of *C. tjantjalka*, for which information is available on habitat, were collected in or among rocky outcrops. SAM R12495 was collected 'on granite outcrops'. SAM R15936a-d was collected 'in small granite outcrops in gullies' and SAM R17701 was 'active on outcrops'. White (1979) collected specimens (SAM R17934a-b, SAM R17935) ' . . . on mid to lower slopes of gibber strewn hills...' John Cornish (pers. comm. 1990) collected SAM R37115 under gibber rocks in a slight gully.

Comparison with Similar Species

Morphology

C. tjantjalka is clearly a member of the *C. decresii* species group (Houston 1974, 1978) in being of moderate size with head and body moderately to strongly depressed, showing sexual dimorphism and being of saxicoline habit. It differs from *C. ornatus* and *C. yinnietharra* in lacking extreme depression of the head and body, and having no clear broad bands of colour around the tail in males. Similarly, the head and body of *C. tjantjalka* are less depressed than those of *C. decresii, C. fionni, C. rufescens* and *C. vadnappa*. The presence of pale spots (in females) or reticulations (in males) on the dorsum distinguishes *C. tjantjalka* from *C. rufescens*, as does the lower number of femoral and preanal pores (Table 1). The snout scales of *C. tjantjalka* are consistently wrinkled, as in *C. vadnappa* (Houston 1974), which serves to distinguish it from *C. decresii* and most *C. fionni*. Male *C. tjantjalka* have pale cream to pale salmon pink areas on the flanks, as opposed to the red or orange areas

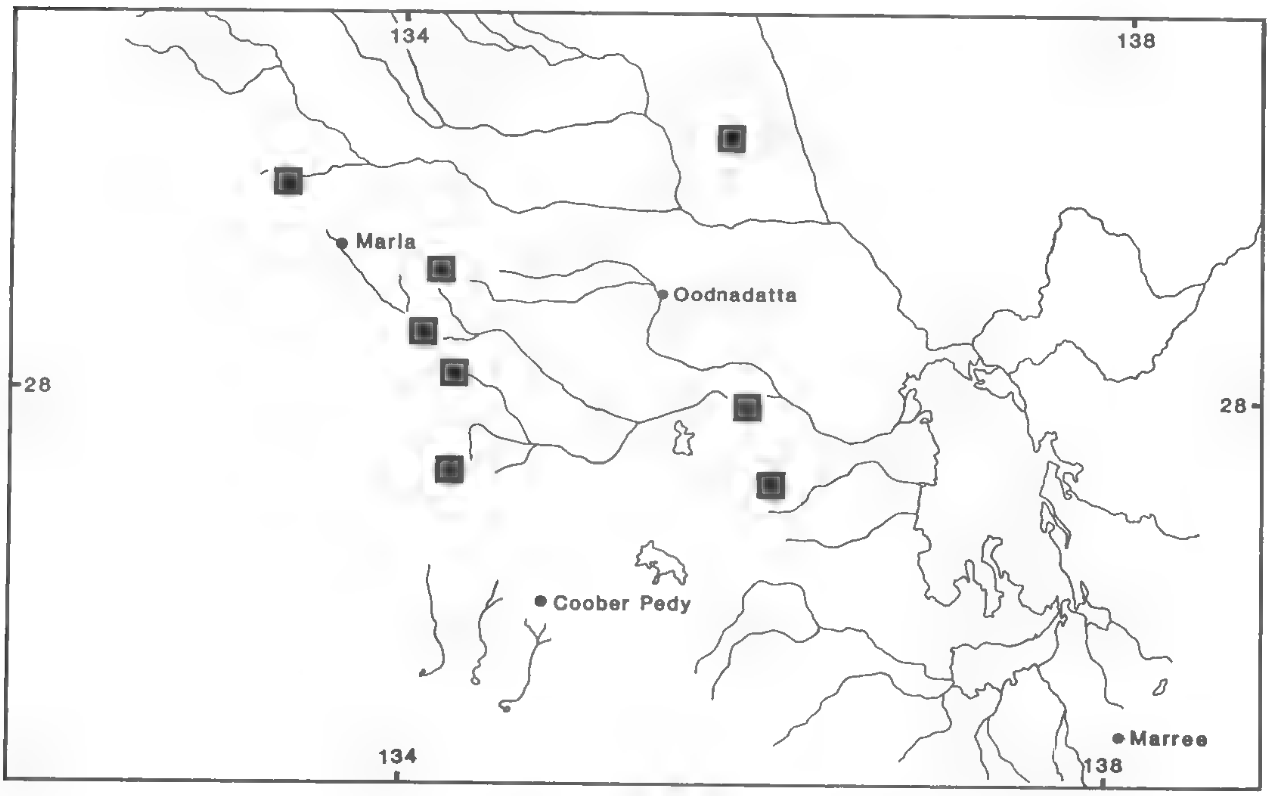

FIGURE 3. Map of northern South Australia showing localities (■) from which *Ctenophorus tjantjalka* has been collected.

on the flanks of male *C. vadnappa*. Male *C. vadnappa* are further distinguished from male *C. tjantjalka* in having a blue background dorsal colour when active. The background colour on the dorsum of *C. tjantjalka* is grey to brown. *C. tjantjalka* and *C. vadnappa* both have a vertebral line of keeled scales present, at least anteriorly, unlike *C. decresii* and *C. fionni* in which any keeled vertebral scales are associated with the nuchal crest only and do not extend behind the shoulders. *C. tjantjalka* lacks the tiny white spiny tubercles found on the flanks of *C. decresii*. Female *C. tjantjalka* may be distinguished from all other members of the *C. decresii* group in having large pale grey spots on the dorsum. The relatively deep head and short snout distinguish both sexes of *C. tjantjalka* from all other members of the *C. decresii* group.

Although all meristic characters counted showed statistically significant differences ($P < 0.01$) between *C. tjantjalka*, *C. rufescens* and *C. vadnappa*, the actual counts for all except FEMPREPO overlapped extensively (Table 1).

Several populations of *C. caudicinctus* are similar in general morphology to members of the *C. decresii* group. This may be due to their being of similar saxicolous habit. Houston (1974) has suggested that the *C. decresii* group may share a common ancestry with some populations currently subsumed under the epithet *C. caudicinctus*. The deeper head and less depressed body of *C. tjantjalka*, relative to other members of the *C. decresii* group, are reminiscent of some populations of *C. caudicinctus*. These taxa may be distinguished by the presence of clusters of small spines on folds of skin on the nape and neck of *C. tjantjalka* which are absent or poorly developed in *C. caudicinctus*. The forelimbs of all members of the *C. decresii* group show negative allometric growth (Table 2; Witten 1985) whereas in *C. caudicinctus* the forelimbs grow isometrically (Witten 1985).

Distribution

C. tjantjalka is allopatric to all other members of the *C. decresii* group and *C. caudicinctus*. The only species which are likely to be confused with *C. tjantjalka* on grounds of distribution are *C. rufescens* and *C. vadnappa*. Both of these species occur on rocky ranges abutting the known distribution of *C. tjantjalka*.

Discriminant Function Analysis

Discriminant function analysis of 15 measurements, using *C. rufescens*, *C. tjantjalka* and *C. vadnappa* as *a priori* groupings (Fig. 4), resulted in correct identification of 92.5% of specimens overall. All *C. tjantjalka*, 93.1% of *C. rufescens* and 89.8% of *C. vadnappa* were correctly grouped. FLL, HLL and HL were not included in the analysis because they failed to contribute significantly to a decrease in Wilk's lambda. A separate discriminant function analysis of eight meristic characteristics, also using *C. rufescens*, *C. tjantjalka* and *C. vadnappa* as *a priori* groupings, resulted in correct identification of 89.0% of specimens overall. All *C. rufescens*, 82.1% of *C. vadnappa* and 83.3% of *C. tjanjalka* were correctly grouped.

The first discriminant function based on measurements accounted for 78.1% of the variance. Unstandardised discriminant function coefficients and their correlations to the discriminant functions are presented in Table 3. Most characters showing the highest correlation with the first discriminant function,

TABLE 1. Comparison of meristic characters for three species of *Ctenophorus*. Values represent mean (standard deviation) over minimum-maximum.

N	*C. rufescens* 55	*C. tjantjalka* 17	*C. vadnappa* 42
FEMPREPO	54.9(2.33) 43-67	38.8(1.96) 33-46	39.7(1.98) 33-47
PRENAS	5.8(0.84) 5-7	4.9(0.85) 3-6	5.1(0.81) 3-6
SUBNAS	6.5(0.85) 5-9	6.2(0.86) 5-7	5.7(0.83) 5-6
INTRANAS	13.1(1.12) 11-17	10.2(1.22) 8-15	10.3(0.97) 8-13
SUPLAB	17.4(1.20) 13-20	18.4(1.06) 13-17	15.0(0.96) 13-16
INLAB	15.6(1.16) 12-19	16.4(1.09) 13-18	15.4(0.90) 14-17
SD4F	19.2(1.15) 16-22	16.6(1.23) 14-19	17.0(1.04) 15-19
SD4T	31.8(1.42) 26-36	28.7(1.63) 24-34	27.6(1.41) 23-33

TABLE 2. Relative growth of body parts in three species of *Ctenophorus*. Regression lines of the form $y = bx^a$ were fitted to the data. R^2 – coefficient of determination; N =sample size; C_{30} = predicted size of body part at a SVL of 30mm; C_{80} = predicted size of body part at a SVL of 80mm. Allometric coefficients were compared to isometry using standard normal deviates: * = P<0.05, ** = P<0.01.

	R^2	a	b	N	C_{30}	C_{80}
			Ctenophorus rufescens			
HLvSVL	0.87	0.8150**	−0.8571	55	6.8	15.1
TLvSVL	0.76	0.9616	0.9794	49	70.1	180.0
FLLvSVL	0.79	0.8254**	−0.0261	55	16.1	36.2
HLLvSVL	0.91	0.8527**	0.6379	55	34.4	79.4
FEMLvSVL	0.82	0.9006	−0.8689	55	9.0	21.7
PLvSVL	0.86	0.7793**	0.0407	55	14.7	31.7
HWDvHL	0.89	0.8997*	0.2417	55	7.1	14.6
HDvHL	0.42	0.7984	0.0140	55	4.7	8.9
SLvHL	0.93	0.9858	−0.6017	55	3.6	8.0
			Ctenophorus tjantjalka			
HLvSVL	0.97	0.9013*	−1.0828	19	7.3	17.6
TLvSVL	0.78	0.8951	1.1501	15	66.3	159.6
FLLvSVL	0.94	0.8379**	−0.0789	19	16.0	36.3
HLLvSVL	0.91	0.8264**	0.7705	19	35.9	80.7
FEMLvSVL	0.91	0.9615	−1.1160	19	8.6	22.1
PLvSVL	0.70	0.6874**	0.4450	19	16.1	31.7
HWDvHL	0.95	0.8813*	0.2544	19	7.4	14.5
HDvHL	0.88	1.0687	−0.5733	19	4.7	10.6
SLvHL	0.94	1.0794	−0.8771	19	3.5	8.1
			Ctenophorus vadnappa			
HLvSVL	0.92	1.0213	−1.5968	40	6.5	17.8
TLvSVL	0.95	1.0676	0.4676	30	60.3	171.7
FLLvSVL	0.92	0.8535**	−0.1758	41	15.3	35.3
HLLvSVL	0.90	0.9424	0.1933	41	29.9	75.4
FEMLvSVL	0.98	1.0563	−1.5685	41	7.6	21.3
PLvSVL	0.76	0.8194*	−0.2254	41	13.0	28.9
HWDvHL	0.61	0.9413	0.0585	40	6.2	15.9
HDvHL	0.94	0.9671	−0.4281	40	4.0	10.6
SLvHL	0.94	0.9412	−0.5052	40	3.5	9.1

which most clearly separates *C. rufescens* from *C. tantjalka* and *C. vadnappa*, are measurements of the limbs. Most characters showing the highest correlation with the second discriminant function, which most clearly separates *C. tjantjalka* from *C. rufescens* and *C. vadnappa*, are measurements of the head. This reflects the differences in the relative proportions of the limbs and heads of the three species (Fig. 5).

Allometry

Relative growth among ten body parts in *C. rufescens*, *C. tjantjalka* and *C. vadnappa* is summarised in Table 2. *C. rufescens* and *C. tjantjalka* share the same pattern of relative growth. The head and limbs show negative allometry with respect to SVL. While the head decreases in size relative to SVL, the head width also decreases in size relative to the head length. Much of the relative shortening of the hindlimb with increasing size is accounted for by negative allometry of the foot.

In *C. vadnappa* only the forelimbs shorten with increasing SVL, while all other body parts grow isometrically. Although overall the hindlimb length grows isometrically with respect to SVL, the proportions of the hindlimb change so that the foot becomes relatively shorter with respect to the rest of the limb.

Witten (1985) has studied relative growth in the majority of species of Australian agamids, but did not have data for *C. rufescens* or *C. vadnappa*. In both of these species and *C. tjantjalka* the tail grows isometrically, whereas Witten (1985) implies that in other species of the *C. decresii* group the tail shows positive allometry. In fact Witten (1982 and pers. comm. 1991) found significant positive allometry in the tail of *C. fionni*, but in other members of the

TABLE 3. Unstandardised discriminant function coefficients (and pooled-within-groups correlations with discriminant functions) of 15 measurements of three species of saxicolous *Ctenophorus*.

Variable	Discriminant Function I	Discriminant Function II
SVL	−0.046(−0.277)	0.193(0.378)
SL	1.232(−0.083)	0.426(0.316)
EYE	0.530(−0.170)	−1.501(0.179)
POCL	1.191(0.175)	0.316(0.327)
SWD	0.032(−0.174)	0.511(0.337)
HWD	−0.101(−0.140)	−0.113(0.194)
HD	0.302(0.003)	−0.271(0.053)
HUML	−0.701(−0.377)	−0.073(0.223)
FAL	0.042(−0.226)	−0.051(0.257)
ML	0.239(−0.229)	0.226(0.344)
FEML	−0.243(−0.305)	−0.130(0.260)
TIBL	−0.039(−0.281)	−0.154(0.185)
PL	−0.060(−0.349)	−0.366(0.097)
AG	−0.009(−0.332)	−0.034(0.358)
TL	−0.023(−0.368)	0.035(0.394)
constant	1.835	0.687
% of variance	78.06	21.94

C. decresii group he studied, the allometric coefficient for tail length was above one but not significantly so. In *C. rufescens* and *C. tjantjalka* the hindlimb shows negative allometry, in concordance with most other Australian agamids, whereas in *C. vadnappa* the hindlimb grows isometrically. Similarly head length in *C. rufescens* and *C. tjantjalka* shows negative allometry, in common with other Australian agamids, whereas the head of *C. vadnappa* grows isometrically. In most species of Australian agamids the forelimb shows negative allometry. The negative allometry or isometry of head width and head depth relative to head length in all three species is unusual among Australian agamids, in which these measurements generally show positive allometry.

Discussion

Ctenophorus tjantjalka is described as a new species primarily on the basis of the remarkable consistency of its morphology across a large geographic range. In general, members of the *C. decresii* complex are characterised by a large amount of population structuring (Gibbons & Lillywhite 1981) and consequent morphological (Houston 1974) and genetic variation (Johnston & Donnellan, unpublished data) among populations within species.

One feature of *C. tjantjalka* is its robust appearance when compared with other members of the *C. decresii* species group, which are moderately to extremely dorsoventrally compressed. In this respect adult *C. tjantjalka* resemble juveniles of other members of the *C. decresii* group. Cogger (1961) has demonstrated that heterochronic processes are an important source of morphological variation among Australian dragon lizards. In the absence of any knowledge of the phylogenetic relationships among the various species groups within the genus *Ctenophorus* it is not possible to determine whether *C. tjantjalka* has arisen through some form of paedomorphosis, or whether it represents a more 'plesiomorphic' form and all other members of the *C. decresii* group have undergone a type of peramorphosis (Alberch *et al.* 1979). This dilemma emphasises the need for a formal phylogenetic analysis of the Australian agamid lizards.

The geographic distribution of *C. tjantjalka* lies directly between those of *C. rufescens* and *C. vadnappa*. It therefore provides evidence to support Houston's (1974) hypothesis that the ancestors of *C. decresii*, *C. fionni* and *C. vadnappa* were once distributed along the western side of Lake Eyre and may have been derived via that route from a common ancestor with *C. rufescens*, among other saxicolous dragon lizards. Gibbons & Lillywhite (1981) have suggested that the *C. decresii* species group may have been derived from a hypothetical ancestor in western Queensland via the corridor of rocky country provided by the Grey Range, Barrier Range and Olary Spur, but there seems to be little to support this alternative hypothesis.

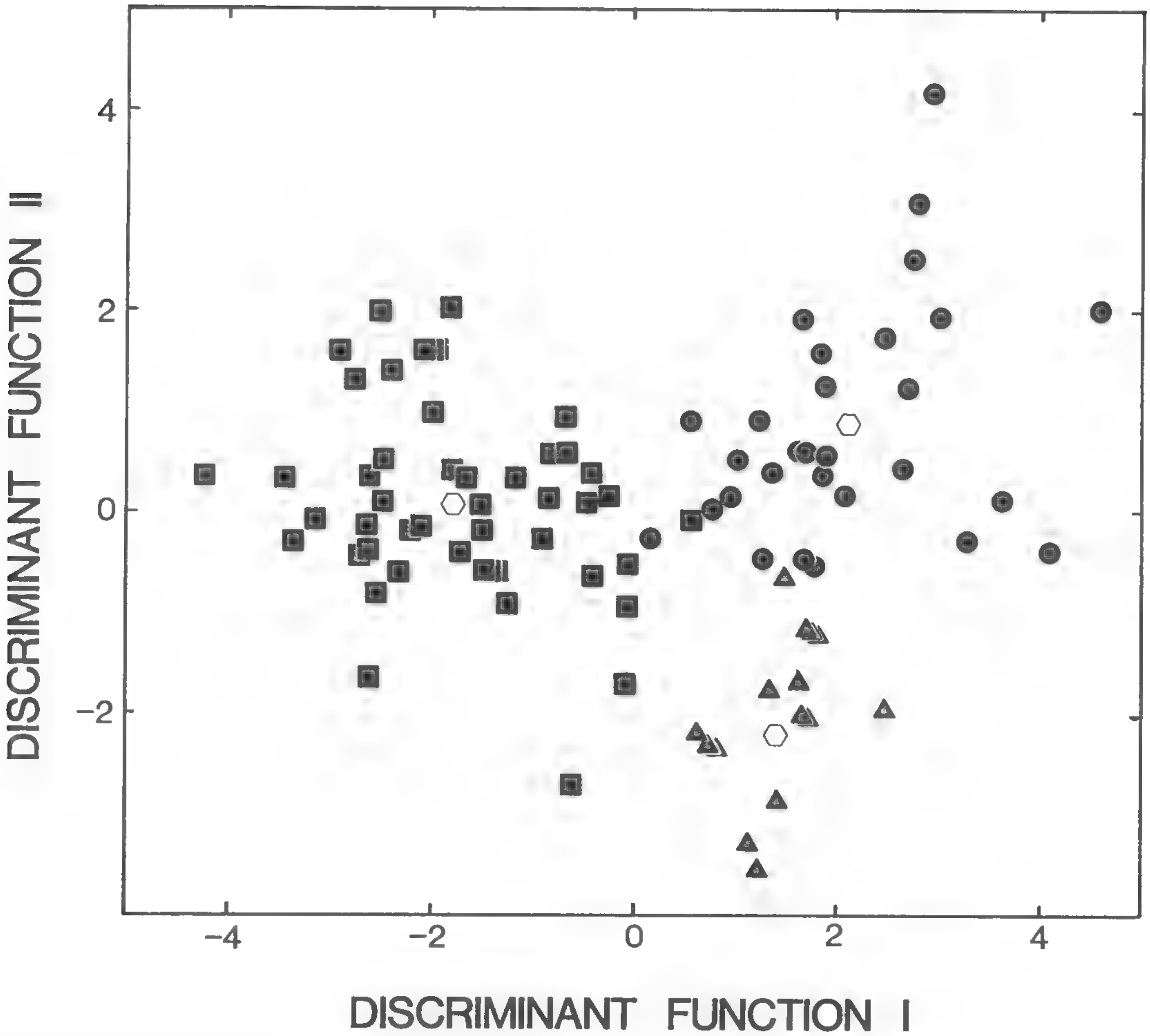

FIGURE 4. Plot of individual *Ctenophorus tjantjalka* (▲), *Ctenophorus rufescens* (■) and *C. vadnappa* (●) on the first two discriminant function axes based on fifteen morphometric characters. (○) = group centroids.

Comparative Material Examined

C. rufescens

WAM R28990-91 Pottoyu Hills (25°19′S, 129°49′E), 10.*v*.1967; SAM R586a-b Everard Range (27°06′S, 132°26′E), no date; SAM R586c Wantapella Swamp (27°02′S, 133°28′E), no date; SAM R1423-25 Mt Sir Thomas, Birksgate Range (27°09′S, 129°44′E), no date; SAM R3125a-c Ernabella Mission (26°18′S, 132°08′E), 10.*x*.1950; SAM R5632 Mann Range (26°01′S, 129°45′E), *vi*.1964; SAM R11754-56 Everard Range (27°06′S, 132° 26′S), 1-7.*xi*.1970; SAM R13219 1.5 miles S Mt Illbillee, Everard Range (27°04′S, 132°29′E), 24.*x*.1972; SAM R13220 nr Mt Davies Bore, Tomkinson Range (26°10′S, 129°08′E), 18.*x*.1972; SAM R13221a-f 3 miles SW Mt Edwin, Mann Range (26°07′E, 129°56′E), 22.*x*.1972; SAM R28274-80, SAM R28289 nr Victory Well, Everard Range (27°03′S, 132°31′E), 25-26.*viii*.1987; SAM R28283-84 between Victory Well and Betty Well, Everard Range (27°03′S, 132°31′E), 26.*viii*.1987; SAM R31772 2.4 km E Mimili (27°01′S, 132°44′E), 10.*xii*.1987; SAM R31773-4 19.2 km W Mimili (26°57′S, 132°32′E), 10.*xii*.1987; SAM R31791, SAM R35828 45.5 km SE Fregon (26°54′S, 132°24′E), 19.*xii*.1987; SAM R33940-2, SAM R33947-48, SAM R35829 Mimili (27°01′S, 132°43′E), 11.*iv*.1989; WAM R31768-80 Mt Lindsay, Birksgate Range (27°02′S, 129°53′E), *viii*.1968; WAM R44341-69 Mt Lindsay, Birksgate Range (27°02′S, 129°53′E), 1.*ix*.1972; WAM R44370-71 Mt Wooltarlinna, Birksgate Range (27°04′S, 129°51′E), 1.*ix*.1972; WAM R44385-87 Mt Kintore (26°34′S, 130°29′E), *ix*.1972; WAM R44341 Blackstone Mining Camp, Blackstone Range (26°01′S, 128°22′S), 29.*viii*.1972.

C. vadnappa

SAM R457 Farina (30°04′S, 138°17′E), 8.*iv*.1915; SAM R3764a-d Marree Picnic Ground (29°39′S, 138°04′E), 1.*xi*.1955; SAM R10959 East Painter Gorge (30°14′S, 139°22′E), 31.*x*.1969; SAM R12505 Yudnamutana (30°10′S, 139°17′E), 10.*ix*.1970; SAM R13547 Terrapinna Spring

(29°58′S, 139°40′E), 17.*vi*.1960; SAM R13943a-b Finniss Creek W Marree (29°38′S, 137°31′E), 10-15.*i*.1974; SAM R14481 Aroona Reservoir (30°35′S, 138°22′E), 15.*i*.1974; SAM R15098a-b Aroona Dam (30°35′S, 138°22′E), no date; SAM R15956a-d Mt Serle (30°32′S, 138°53′E), 10.*iv*.1977; SAM R16159 Mt Serle (30°31′S, 138°55′E), 4.*ix*.1977; SAM R16189a-b Termination Hill, 26km W Lyndhurst (30°15′S, 138°03′E), 8.*x*.1977; SAM R19284 10 miles W Arkaroola village (30°47′S, 138°30′E), 16.*ii*.1981; SAM R19884-5 15km W Copley (30°30′S, 138°25′E), 25.*iv*.1981; SAM R24430-31 W end Brachina Gorge, Flinders Ranges (31°21′S, 138°33′E), 20.*viii*.1983; SAM R24906-7 Grindells Hut, Gammon Ranges (30°28′S, 139°12′E), 25.*xi*-1.*xii*.1983; SAM R28098 5km N Copley (30°30′S, 138°25′E), 16.*viii*.1985; SAM R28625-6 Arkaroola (30°20′S, 139°22′E); SAM R29575 Marree Picnic Ground (29°39′S, 138°04′E), 23.*viii*.1985; SAM R30051-3 30.6km S Lyndhurst (30°32′S, 138°25′E), 21.*ix*.1985; SAM R30054 3.5km S Arkaroola (30°22′S, 139°27′E), 31.*ix*.1985; SAM R30999 32km S Lyndhurst (30°32′S, 138°25′E), 8.*xi*.1986; SAM R31002 Aroona Dam (30°35′S, 138°22′E), 23.*viii*.1986; SAM R31216 5.4km NW Copley (30°32′S, 138°25′E), 8.*xi*.1986; SAM R31219-22 Italowie Gap, Gammon Ranges (30°33′S, 139°10′E), 4-8.*iv*.1985.

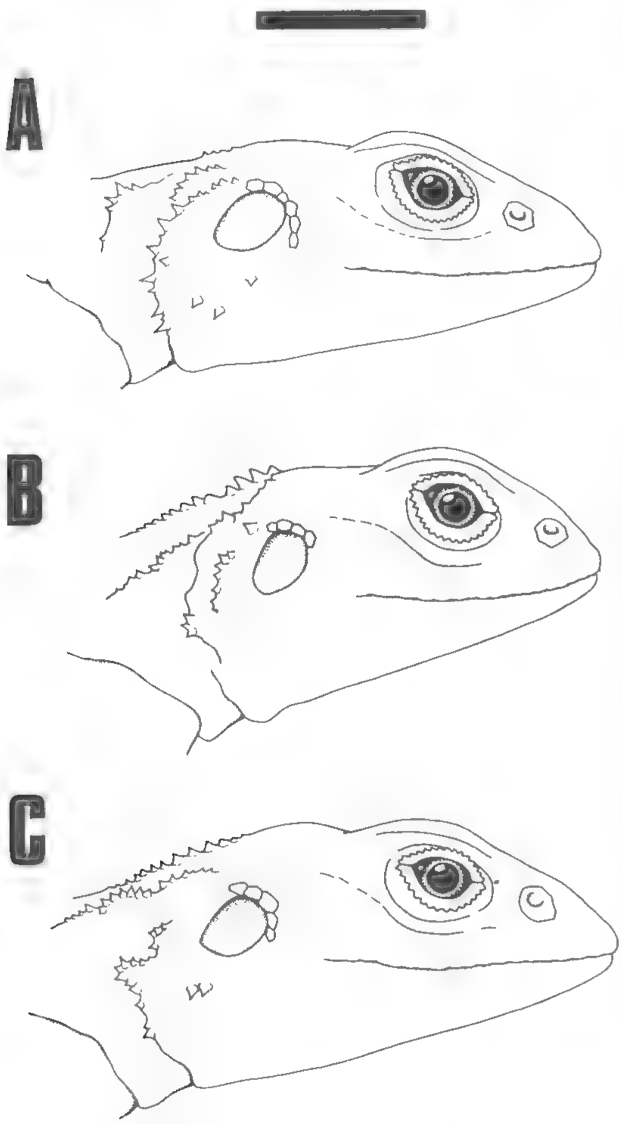

FIGURE 5. Lateral views of the heads of adult male (A) *Ctenophorus rufescens* (SAM R13221c), (B) *Ctenophorus tjantjalka* (SAM R17934a) and (C) *C. vadnappa* (SAM R16189a). Scale bar = 10mm.

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THE CROCKERS WELL METEORITE : AN UNUSUAL LL7 BRECCIA FROM SOUTH AUSTRALIA

MARGARET E. WALLACE

Summary

The Crockers Well, South Australia, meteorite is a rare type LL7 chondrite. The 3.8 gram stone was found in 1956 by J.E. Johnson. Crockers Well has a brecciated texture and a mineral chemistry which indicates that it is an LL-type chondrite. It has equilibrated at unusually high temperatures (950 to 1 100°C) and appears to be a shock breccia which has recrystallized at depth. Crockers Well is the first LL7-type meteorite to be found in Australia and is similar to the Antarctic meteorites Yamato 74160 and Yamato 791067.

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WALLACE, M. E. 1992. The Crockers Well meteorite: An unusual LL7 breccia from South Australia. *Rec. S. Aust. Mus.* **26**(1): 61–65.

The Crockers Well, South Australia, meteorite is a rare type LL7 chondrite. The 3.8 gram stone was found in 1956 by J. E. Johnson. Crockers Well has a brecciated texture and a mineral chemistry which indicates that it is an LL-type chondrite. It has equilibrated at unusually high temperatures (950 to 1 100 °C) and appears to be a shock breccia which has recrystallized at depth. Crockers Well is the first LL7-type meteorite to be found in Australia and is similar to the Antarctic meteorites Yamato 74160 and Yamato 791067.

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Manuscript received 29 November 1991.

The Crockers Well meteorite weighing 3.8 grams was found in 1956 by James Eric Johnson, of the South Australian Department of Mines and Energy. Mr Johnson was surveying for uranium when he found the small meteorite on a granite hill 0.4 kilometres north of the East Crocker uranium prospect, near Crocker Well camp, north–west of Plumbago Homestead, County Lytton, South Australia (32°01′S, 139°47′E, see Fig. 1). Only one specimen was found.

The meteorite was presented to the South Australian Museum by Mr Johnson in 1956 and the discovery recorded by Corbett (1968). The name Crockers Well used in this report is synonymous with Crocker Well and Crocker's Well (Clarke 1976; Fitzgerald 1979; Graham *et al.* 1985) and has been approved by the nomenclature committee of the Meteoritical Society.

The meteorite is a small button-shaped stone (18 × 15 × 12 mm) with a fusion crust coating one side. It is moderately iron-stained. Due to its small size, the stone remained uncut in the museum's collection for 34 years and thus was only described as an unclassified chondrite. Fitzgerald (1979) suggested that it may be related to Ethiudna, a large 74.32 kilogram chondrite found 6.5 kilometres away.

In 1990 a thin-section was made in order to gain textural and mineralogic information and to classify the meteorite properly. In making the thin-section, special care was taken not to damage the fusion crust as this is important for establishing the meteorite's extraterrestrial origin. The remaining 2.38 gram piece resides in the meteorite collection of the South Australian Museum (catalogue number G5909). A brief description and classification of the meteorite was presented by Wallace & Pring (1991). The stone is not related to Ethiudna but is a rare type LL7 chondrite of which only three examples have been found to date. This paper presents a detailed petrographic and mineralogic description of the Crockers Well meteorite in order to provide constraints on the origin and physical history of this rare type of chondritic meteorite.

Texture

In thin-section, Crockers Well has a brecciated texture with no visible chondrules. It is composed of large clasts and rounded olivine grains set in a finer grained matrix of broken olivine, pyroxene and feldspar fragments (Fig. 2). The clasts are sub-angular, up to 7 mm across, coarsely crystalline and composed of olivine, orthopyroxene, clinopyroxene, plagioclase and chromite with minor amounts of chlorapatite and metal. Within the clasts, the silicate minerals generally have a granoblastic texture with good triple point boundaries, typical of recrystallization. Some remnant but now recrystallized poikilitic textures are also preserved. Mineral grains are coarse for a chondrite, up to 200μm in size. In addition to clasts there are some large fragments of olivine, up to 3 mm in size, which have rounded boundaries and show some fracturing. Olivine grains have straight extinction, so appear to be relatively unstrained. They contain many small inclusions of orthopyroxene, plagioclase and troilite. The matrix is an assemblage of poorly sorted broken fragments of silicate minerals. Finer matrix material appears to be recrystallized and no glass was detected. Iron-nickel metal and troilite are present only in the clasts and do not occur as part of the matrix assemblage. A thin glassy fusion crust is present along one side of the thin-section.

Mineral Chemistry

Crockers Well is an olivine, two pyroxene, plagioclase and chromite assemblage with minor amounts of chlorapatite, iron-nickel and troilite. Compositions of the silicate phases were analyzed with a JEOL electron microprobe using an EDS system at the University of Adelaide. Analyses were made using an accelerating voltage of 15 kV, a sample current of 5 nA, and a beam width of 5μm. In order to analyse equilibrium assemblages sample points were selected

in seven distinct clasts within the thin-section. These areas are indicated in Fig. 2. Three matrix areas were also analysed to determine if matrix mineralogy was different from clast mineralogy and random analyses were performed throughout the section in order to detect any heterogeneity. Representative crystal analyses are presented in Table 1. All silicate analyses obtained have been plotted in Fig. 3.

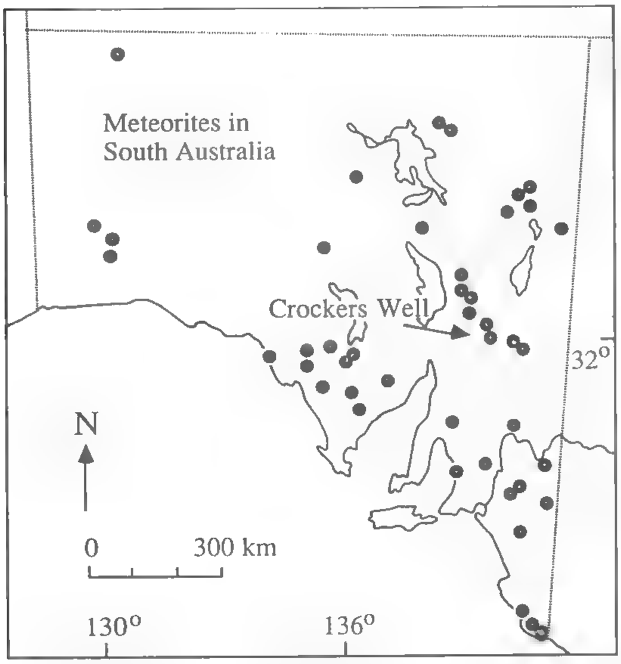

FIGURE 1. Map of South Australia showing location of Crockers Well and sites of other meteorite finds in the state.

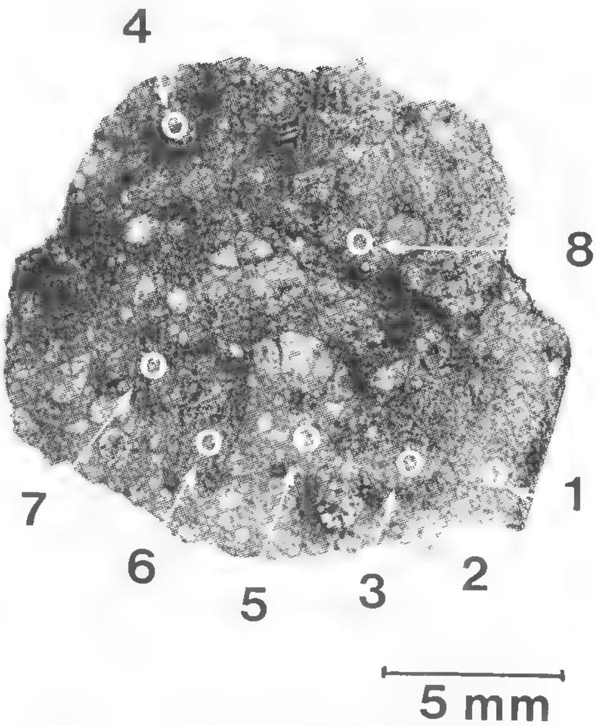

FIGURE 2. Thin-section microphotograph of Crockers Well. Numbers show areas of detailed microprobe analyses.

Olivine

Olivine is equilibrated showing a narrow range in composition with a mean fayalite content of $Fa_{30.0 \pm 0.5}$ (32 analyses). Calcium content was below the detection limit of the microprobe. There was no chemical difference detected between matrix, clast or large olivine crystals.

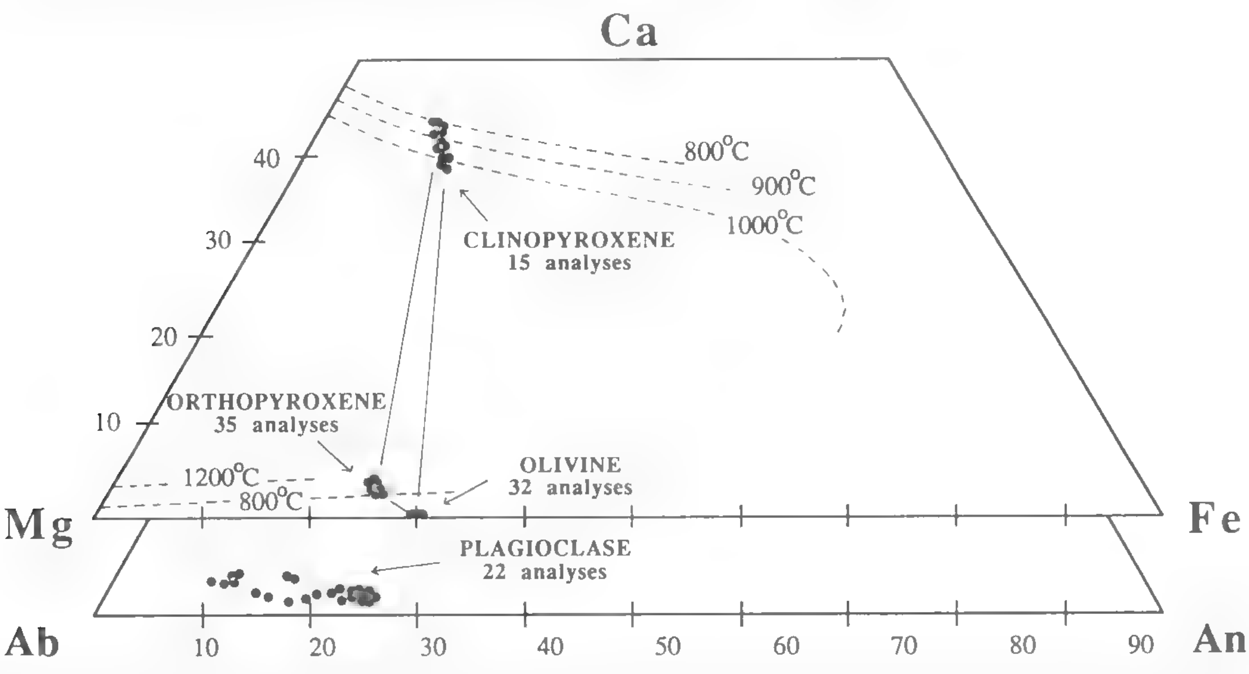

FIGURE 3. Silicate mineral chemistry of Crockers Well plotted as mol. % Ca, Mg, and Fe for olivine and pyroxenes, and Ab (albite), An (anorthite) and Or (orthoclase) endmembers for feldspars. Isotherms show temperature calculations based on the calcium content of orthopyroxene and clinopyroxene from Lindsley (1983).

Orthopyroxene

Orthopyroxene has a very narrow range of compositions with no detectable zoning within grains nor a chemical variation between grains within the matrix or clasts. Orthopyroxene iron content represented by the ferrosilite component is $Fs_{23.9 \pm 0.8}$ (34 analyses). This is particularly iron rich, but within the range of LL group chondrites as shown in Fig. 4 (Keil & Fredriksson, 1964). The high iron content of both the olivine and orthopyroxene suggests that the meteorite is highly oxidized. The orthopyroxenes have a distinctly high calcium content with the wollastonite component varying from $Wo_{2.5}$ to $Wo_{4.0}$ (mean of $Wo_{3.2}$). This is very calcium rich for ordinary chondrites but within the range of the high temperature type 7 grouping (>1.0% CaO, Dodd 1981).

Clinopyroxene

Clinopyroxene compositions range in ferrosilite content from $Fs_{9.9}$ to $Fs_{12.8}$, and wollastonite content of $Wo_{39.2}$ to $Wo_{43.6}$ (16 analyses). They are augites which are particularly high in sodium (0.6 to 1.01 wt% Na_2O) and chromium (1.04 to 1.57 wt% Cr_2O_3). Typically LL6 chondrites contain 0.5 wt% Na_2O and 0.6 wt%Cr_2O_3. The clinopyroxenes in Crockers Well are similar to those found in the Yamato 74160 (LL7) meteorite. Yamato 74160 contains augites with 0.53-0.66 wt% Na and 0.86-1.52 wt% Cr (Takeda *et al.* 1984). Takeda *et al.* (1984) suggest that this results from a high ureyite ($NaCrSi_2O_6$) component indicating either a high temperature or coexistence with a melt. Geothermomic calculations using the two pyroxene geothermometer of Wells (1977) based on the distribution of calcium in coexisting ortho- and clinopyroxenes show that Crockers Well reached temperatures between 950 and 1 100°C.

Plagioclase

Plagioclase crystals are very large up to 150 μm and show the widest range in composition, $Ab_{74.4-91.3}$ $An_{6.5-24.1}$ $Or_{1.2-4.3}$ (30 analyses). The chemical distribution is shown in Fig. 3. A thin lamellar structure can be seen in thin-section but was not chemically distinct enough to find by microprobe imaging.

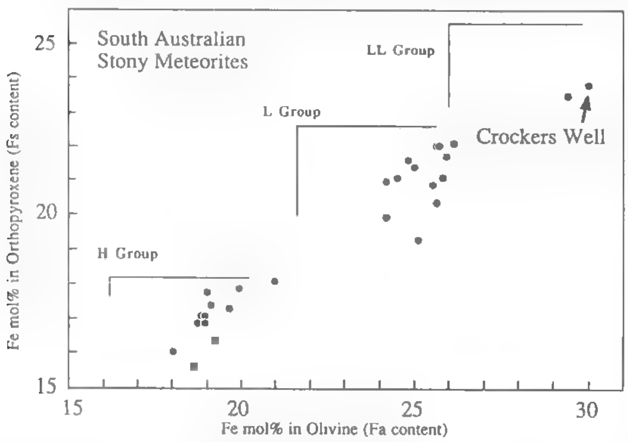

FIGURE 4. Iron contents expressed as mol. % Fe in olivine (Fa) and orthopyroxene (Fs) of South Australian stony meteorites. Classification groups are from Keil & Fredriksson (1964).

Opaque minerals

Opaque minerals are chromite, troilite and iron-nickel metal. They occur as equigranular grains within clasts. Chromite in Crockers Well is richer in Cr and Fe and poorer in Al than normally found in chondrites (as described by Bunch *et al.* 1967). High iron may be due to a higher than normal oxygen fugacity while high chromium reflects abnormally high temperatures. The sulphide is troilite with no detectable nickel. Iron-nickel metal is predominantly taenite. No martensite was found.

Discussion

Although Crockers Well has a brecciated rather than chondritic texture, mineral chemistry indicates that the meteorite was formed from LL-type chondritic material. The compositions of the minerals are similar to those found in ordinary chondrites, except that element partitioning (particularly Ca, Na and Cr) between silicate phases indicates that the meteorite equilibrated at unusually high temperatures (950 to 1 100°C) and under relatively oxidizing conditions. The silicate minerals in the type LL7 chondrites Yamato 74160, Yamato 791067 and Uden have a similar compositional range (Takeda *et al.* 1979, 1984; Yanai & Kojima 1987; Heyse 1978). The presence of metal in clasts, but rarely within matrix material, suggests that the meteorite may have partially melted near the FeS-Fe eutectic at 1 000°C.

Brecciated textures in LL-type meteorites are normally attributed to shock processes. Strongly shocked meteorites are characterised by severe melting, vesiculation, presence of a brown glassy matrix, maskelynite instead of plagioclase and martensite rather than kamacite and taenite (Stoffler *et al.* 1988; Okano *et al.* 1990). These shock features are not present in Crockers Well. Evidence of shock is restricted to extreme brecciation and possibly to the mobility of metals. Crockers Well may, however, be a shock breccia which has recrystallized and equilibrated at depth. Slow cooling after brecciation would result in recrystallization of glass and fine matrix material while preserving a record of high temperature in the silicate compositions. A thermal history study of Crockers Well involving compositions of the coexisting metals kamacite and taenite (Wood 1967) may provide further constraints.

In summary, Crockers Well is an LL7-type meteorite. Its brecciated texture and high temperature mineral chemistry record a period of intense shock. Slow cooling at depth in its parent body has resulted in the

TABLE 1. Representative electron microprobe analyses (EDS), Crockers Well meteorite.

	Clast #1	#1b	#4	#5	#8	Matrix	Matrix b
Olivine							
SiO_2 wt%	37.47	–	37.40	37.50	37.77	37.40	37.78
FeO	27.46	–	27.01	28.06	27.55	27.72	26.70
MnO	0.31	–	0.26	0.38	0.40	0.28	0.30
MgO	36.31	–	36.04	36.22	36.44	35.71	35.73
Total	101.55	–	100.71	102.16	102.16	101.11	100.51
Mg#	70.2	–	70.4	69.7	70.2	69.7	70.5
Orthopyroxene							
SiO_2	54.62	54.95	55.40	55.41	55.77	55.53	55.32
Al_2O_3	0.13	0.24	0.19	0.10	0.10	0.47	0.34
Cr_2O_3	0.16	0.34	0.15	0.28	0.37	0.53	0.19
FeO	15.71	15.37	15.99	16.12	15.89	15.94	16.72
MnO	0.39	0.19	0.35	0.25	0.44	0.34	0.32
MgO	26.79	26.99	27.08	27.49	27.12	26.89	27.69
CaO	1.58	1.84	1.34	1.64	1.74	2.06	1.34
Total	99.38	99.92	100.50	101.29	101.43	101.76	101.92
Mg#	72.9	73.1	73.2	72.9	72.7	72.1	72.8
Fe#	24.0	23.3	24.2	24.0	23.9	24.0	24.7
Ca#	3.1	3.6	2.6	3.1	3.4	4.0	2.5
Clinopyroxene							
SiO_2	54.37	–	54.48	53.98	53.62	54.80	53.74
TiO_2	0.30	–	0.28	0.27	0.30	0.32	0.26
Al_2O_3	0.65	–	0.54	0.85	0.48	0.93	0.60
Cr_2O_3	1.38	–	1.37	1.57	1.27	1.47	1.09
FeO	7.11	–	6.86	7.65	7.67	7.98	7.32
MgO	16.46	–	16.23	16.29	16.31	16.89	16.32
CaO	19.81	–	20.44	19.15	18.89	19.19	19.51
Na_2O	0.90	–	0.85	0.81	0.75	0.82	0.77
Total	100.98	–	101.05	100.57	99.29	102.40	99.61
Mg#	47.4	–	46.7	47.4	47.7	48.0	47.4
Fe#	11.5	–	11.1	12.5	12.6	12.7	11.9
Ca#	41.1	–	42.3	40.1	39.7	39.2	40.7
Plagioclase							
SiO_2	64.18	65.50	64.37	67.24	66.73	64.97	64.15
Al_2O_3	23.43	22.11	23.17	20.98	21.62	22.31	21.61
FeO	0.81	0.38	0.27	0.76	0.36	0.80	0.94
CaO	4.84	3.41	4.51	2.08	2.69	3.95	3.37
K_2O	0.33	0.50	0.36	0.74	0.65	0.28	0.63
Na_2O	8.80	9.57	9.02	9.53	9.27	9.50	9.18
Total	102.39	101.47	101.70	101.33	101.32	101.81	99.88
Ab	75.3	80.4	76.8	85.4	82.9	80.1	80.1
An	22.9	15.8	21.2	10.3	13.3	18.4	16.2
Or	1.9	3.8	2.0	4.3	3.8	1.5	3.6
Chromite						**Apatite**	
TiO_2	1.99	–	2.34	3.27	1.97	P_2O_5	41.55
Al_2O_3	4.14	–	5.46	4.50	5.46	FeO	0.22
Cr_2O_3	57.58	–	59.43	59.24	60.21	CaO	53.67
FeO	32.95	–	32.32	33.12	31.83	Na_2O	0.32
MnO	0.44	–	0.48	0.34		Cl	8.54
MgO	1.54	–	1.60	1.60	1.90		
Total	98.64	–	101.63	102.07	101.37		104.30

Mg#=Mg/(Mg+Fe) cations, Fe#=Fe/(Fe+Mg+Ca) cations, Ca#=Ca/(Fe+Mg+Ca) cations
Ab=albite, An=anorthite, Or=orthoclase end member compositions

recrystallization of fine grained matrix material, equilibrium of mineral phases and the preservation of high temperature mineral chemistry.

The meteorite record has provided many examples of brecciated LL-type chondrites most of which are interpreted as surface regolith material from the LL-parent body. These chondrites show various degrees of shock melting, recrystallization and brecciation due to intense impacts. Crockers Well appears to be one of the more unusual meteorites which preserves a record of shock-melting but also shows subsequent recrystallization at depth.

Acknowledgments

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A NEW GENUS OF THE BRYOZOAN SUPERFAMILY SCHIZOPORELLOIDEA, WITH REMARKS ON THE VALIDITY OF THE FAMILY LACERNIDAE JULLIEN, 1888

S. A. Parker & D. P. Gordon

Summary

Vitrius gen. nov. is proposed for the cheilostome bryozoan Schizoporella insignis Hincks (Recent, Africa, Australia and New Zealand). It appears to be related to Lacerna Jullien, Phonicosia Jullien and Cribellopora Gautier, sharing with them a calcareous cryptocystidean shield with conspicuous areolae, bordered by a narrow gymnocyst, and a membranous ovicellular ectooecium (i.e., the endooecium being the exposed skeletal surface). The little-known family Lacernidae Jullien, essentialy unused for more than a century, is here considered available for genera with the above suite of characters as well as the presence of complex pore-occlusions in some of the genera.

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PARKER, S. A. & GORDON, D. P. 1992. A new genus of the bryozoan superfamily Schizoporelloidea, with remarks on the validity of the family Lacernidae Jullien, 1888. *Rec. S Aust. Mus.* **26**(1): 67–71.

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In the course of routine examination of the bryozoan collections in the South Australian Museum (SAM), the Western Australian Museum (WAM) and the New Zealand Oceanographic Institute (NZOI), three Recent samples from South Australia, Western Australia and Stewart Island, New Zealand were identified as *Schizoporella insignis* Hincks, 1881. Previously known from Africa (Hincks 1881) and South Australia (MacGillivray 1891), the species differs markedly from *Schizoporella* Hincks, 1877 sensu stricto, and a new genus is here proposed for it. The new genus shares some important features with *Lacerna* Jullien, 1888 and related genera. The group appears to merit recognition as a discrete family within the Schizoporelloidea for which the little-used name Lacernidae Jullien, 1888 is available.

Systematics

Order Cheilostomida Busk, 1852
Suborder Ascophorina Levinsen, 1909
Infraorder Lepraliomorpha Gordon, 1989
Superfamily Schizoporelloidea Jullien, 1883
Family Lacernidae Jullien, 1888

Vitrius Parker & Gordon, gen. nov.

Generic diagnosis

Colony encrusting. Zooids glassy, the frontal shield cryptocystidean, with a ring of lateral pores that also encircles the orifice, the porous margin rimmed by gymnocystal calcification. Proximal rim of orifice more or less straight with a distinct sinus. Oral spines and avicularia absent. Ovicell prominent, the endooecium smooth, minutely pitted, the ectooecium entirely membranous; closed by the zooidal operculum. Basal pore-chambers present.

Type species

Schizoporella insignis Hincks, 1881.

Etymology

The generic name *Vitrius* is derived from the Latin adjective *vitreus*, meaning glassy or transparent.

Remarks

Vitrius differs from *Schizoporella* Hincks, 1877 in having glassy zooids, a centrally imperforate frontal shield with conspicuous marginal pores only, a well-developed gymnocystal rim, uncalcified ectooecium, and closure of the ovicell by the zooidal operculum. It is similar to three other schizoporelloidean genera, *Lacerna* Jullien, 1888, *Phonicosia* Jullien, 1888, and *Cribellopora* Gautier, 1957, in important features of the frontal shield and ovicell, though differing in details – *Lacerna* has oral spines, short radii in the frontal-shield pores, scarcely any gymnocyst, and a low rim of ectooecial calcification bordering the ovicell; *Phonicosia* has oral spines, avicularia, reduced gymnocyst, minutely pitted complex pore-closures, and an ovicell not closed by the zooidal operculum; *Cribellopora*, which has one or no oral spines, is characterized by complex pores with complete radii. *Vitrius* is at present monotypic.

Vitrius insignis (Hincks, 1881)
(Figs 1, A-D)

Schizoporella insignis Hincks, 1881: 134, pl. 5, fig. 10; MacGillivray 1891: 82, pl. 9, fig. 8.

Type locality

Africa – no further details given by Hincks.

Material examined

New Zealand: off South Cape, Stewart Island, 55 m, no other data NZOI Z6892; *South Australia:* Boston Bay, southern Eyre Peninsula, no other data (probably collected by O'Halloran *ca* 1890), small ancestrulate colony on seagrass, *Posidonia* sp., SAM L667; *Western Australia:* north side of Beacon Island, Houtman Abrolhos, 25.vi.1985, coll. S. M. Slack-Smith, three small ancestrulate colonies on seaweed, *Sargassum* sp., WAM 632-91.

The sample from Port Wakefield, South Australia listed and figured as *Schizoporella insignis* by MacGillivray (1891) cannot be found in the Museum of Victoria (T. Stranks *in litt.* 12.ix.1991).

Distribution

Stewart Island, New Zealand; South Australia; Houtman Abrolhos, Western Australia; (?southern) Africa.

Description

Colony encrusting, small. Zooids hyaline, 0.38-0.51 × 0.23-0.38 mm the frontal shield with a ring of relatively large simple pores that also encircles the orifice, the porous area bounded by, and set within, a rim marking the edge of the surrounding gymnocyst, with many of the pores occurring partly under the rim; the central area of shield smooth, with a short umbo. Orifice proportionately large in relation to the zooid transversely D-shaped, with a straight proximal rim, and a subcircular sinus that is constricted distally. Opercular tab articulated, and set off from the rest of the operculum by a sclerite. No oral spines or avicularia. Ovicell prominent, closed by the zooidal operculum, the endooecium wholly exposed, more or less smooth, with a minutely pitted area, the ectooecium membranous. Interzooidal communications comprising widely open basal pore-chambers, sealed externally by a membrane, with string of simple pores along each septulum. Ancestrula with a membranous frontal wall, no spines.

Remarks

Thanks to the courtesy of Mr P. J. Chimonides of the Natural History Museum, London, we have been able to examine scanning electron micrographs of the holotype of *Schizoporella insignis*. It is in extremely poor condition, being scarcely recognizable as bryozoan, comprising three separated zooids, one of which is broken and all three covered with debris. Only part of the proximolateral gymnocyst and a lateral septulum of one zooid give a clue as to identity, and these features accord with what we have seen in the Australasian specimens.

The illustrations of Hincks (1881) and MacGillivray (1891) both show a feature of the frontal shield not appreciated by SEM but rather seen in transparency, *i.e.*, a line bisecting the marginal pores. This line is the inner edge of the narrow gymnocyst, which may cover half the area of many or most of the pores. These pores are the simplest among the genera here recognized as lacernid, lacking calcareous radii or other occlusions though a narrow flange-like rim may occur within the pore.

The articulation of the operculum is not uncommon among schizoporelloideans. One genus, *Arthropoma* Levinsen, 1909, is named after this feature, but it is possibly to be expected wherever the zooidal operculum is used also to seal the ovicellular orifice and the broad anterior flap (porta) moves through an arc of some 30°-40° relative to the plane of the tab (vanna) sealing the orificial sinus. The articular sclerite in *Vitrius* can easily be seen in the intact operculum even by reflected light.

As Hincks (1884) pointed out, *Schizoporella insignis* MacGillivray 1883 is a junior primary homonym of *S. insignis* Hincks, 1881 and cannot be retained. It is superseded by its later name *Schizoporella daedala* MacGillivray, 1887 (=*Chiastosella daedala:* Stach 1937).

Discussion

The characters of *Vitrius* appear to ally the genus (at present monospecific) with *Lacerna* Jullien, 1888, *Phonicosia* Jullien, 1888, and *Cribellopora* Gautier, 1957, traditionally included in the family Schizoporellidae Jullien, 1883. *Lacerna* is the type genus of the family Lacernidae Jullien, 1888, which was introduced for it and *Phonicosia*. Jullien's familial diagnosis is brief and rather general — our paraphrase of his French is 'Orifice with the distal rim arched; the posterior rim straight, with a median sinus; the lateral row of pores can occur in two series distally'. With only one hesitant exception, the family name Lacernidae has not, to our knowledge, been used since. Even Calvet (1904), who worked with Jullien (*e.g.*, Jullien & Calvet 1903), included the type species of *Lacerna* in *Schizoporella*. The one exception is Harmer (1957), who posthumously cited the family as comprising only *Lacerna* (which he wrongly considered to include *Buffonellodes)* and possibly *Aimulosia*, but a footnote by A. B. Hastings states that, in unpublished notes, Harmer indicated that he considered merging the Lacernidae in the Schizoporellidae.

Jullien's (1888) diagnosis of the family was trivial, noting features sometimes scarcely useful at the species-level. Furthermore, the type genus and species (*Lacerna hosteensis*) were incompletely described and illustrated, remaining so until very recently. Waters's (1904) apparent redescription was of another species, recently named as *Lacerna watersi* (Hayward & Thorpe 1989). López Gappa (1977) gave a good illustration of fertile *L. hosteensis* and Hayward (1991)

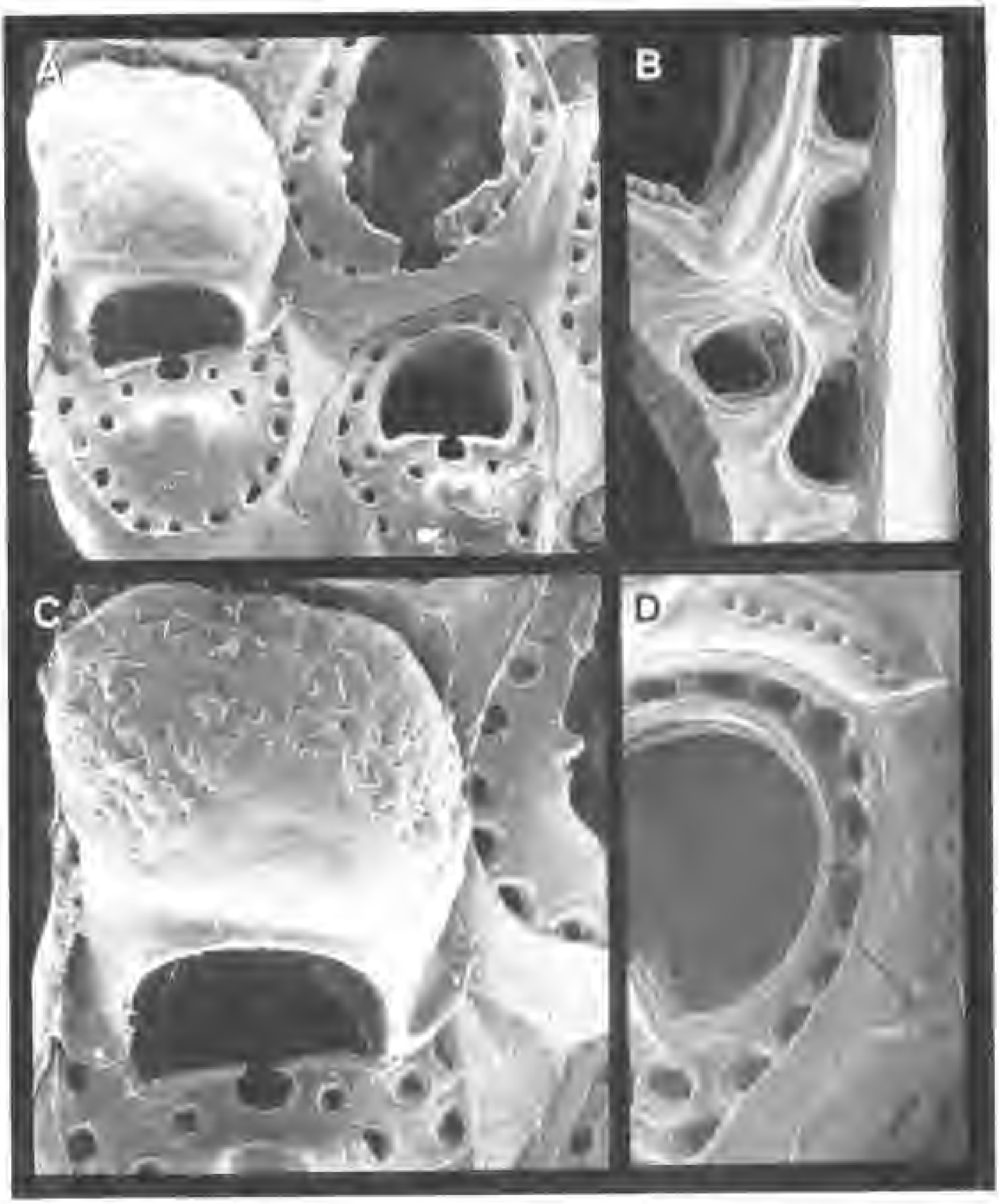

FIGURE 1. *Vitrius insignis* (Hincks), from off South Cape, Stewart Island, New Zealand. A, Group of zooids. B, Close-up of lateral pores at the edge of the gymnocyst adjacent to the orifice. C, Ovicell. D, Widely open pore-chambers distal to the orifice.

examined the type specimen and illustrated the species by SEM. Thus it is now possible to evaluate the distinctiveness of the Lacernidae for the first time. Hayward (1991) did not assign *Lacerna* to a family but, *inter res,* discussed the status of *L. eatoni* (Busk, 1876), noting its general appearance to *Phonicosia* and pointing out that López Gappa (1978) had assigned it to *Cribellopora.* These associations accord with our conclusion that these three genera, with *Vitrius,* are closely related and may be grouped together.

Whatever the eventual constitution or reconstitution of the Schizoporellidae, the lacernid genera *Lacerna, Vitrius, Phonicosia* and *Cribellopora* cannot be regarded as confamilial with *Schizoporella sensu stricto,* and the family Lacernidae Jullien, 1888 is here used to accommodate them. The Lacernidae may be distinguished from the Schizoporellidae *sensu stricto* primarily on the basis of the ovicell, which in the former has only a single calcified layer, the endooecium (the ectooecium being entirely membranous), and which develops in the manner described by Nielsen (1981) for *Fenestrulina* Jullien, 1888. For the Schizoporellidae *s. s.*, the development of the ovicell has, remarkably, not yet been described, but from our preliminary SEM examination of *Schizoporella errata* (Waters, 1878) we conclude that in this family both ovicellular layers are calcified and fused, with the intervening space obliterated. Even if it should be shown that the ectooecium of *Schizoporella s. s.* is membranous, however, significant differences between the Schizoporellidae and the Lacernidae remain, *e.g.* the lacernid ovicell is not overlaid by thick secondary calcification and the hypostegal coelom of the distal zooid. Additional features of the Lacernidae include a mostly centrally imperforate frontal shield that tends not to become thickly calcified but often remains hyaline, a vestigial to proximolaterally well-developed gymnocyst, and marginal pores that can have quite complex occlusions. In *Lacerna* the pores are simple openings early in zooidal ontogeny, but soon develop short simple radii that do not meet in the centre of the pore. In *Cribellopora* the pores develop as in *Lacerna,* but the radii meet and fuse in the centre of each pore, and in some species a fine calcareous mesh may further develop between the radii. In *Phonicosia* a fine mesh without distinct radii occurs, partly or totally occluding the pore-opening when fully developed. *Vitrius* lacks radii or a mesh, having only a narrow circular flange within each pore. Some or all of these pores in these genera are areolar, containing a rosette of transporting cells by which the main body cavity of the zooid (perigastric coelom) communicates with the thin cavity above the cryptocystidean shield (hypostegal coelom) (*see* Banta 1970, 1971, 1973). The presence of significant pore-occlusions, especially in *Phonicosia,* would seem to prevent or severely restrict effective nutrient transport to the hypostegal coelom and perhaps it is significant that frontal budding (which requires such transport) has not been reported in these genera. The apparent lack of secondary calcification may be another possible sign of restricted nutrient transfer.

Insofar as they have basal pore-chambers, *Lacerna, Phonicosia* and *Vitrius* share the same method of budding new zooids – intrazooidal in the terminology of Lidgard (1985). *Cribellopora* lacks basal pore-chambers and budding is zooidal (Lidgard 1985).

Diagnosis of Lacernidae Jullien, 1888

Colony encrusting. Zooids with a relatively thin crypocystidean shield, partly or mostly imperforate centrally, the lateral pores often with complex closures, the frontal area bordered by a vestigial to well-developed proximolateral gymnocyst. Orifice with a distinct sinus, the operculum sometimes articulated. Oral spines and avicularia present or absent. Ovicell with frontally imperforate calcified endooecium and entirely membranous ectooecium. Basal pore-chambers or mural septula present; budding thus intrazooidal or zooidal. Constituent genera: *Lacerna, Phonicosia, Vitrius, Cribellopora.*

Stratigraphic range of Lacernidae

Eocene to Recent. An undescribed species of *Cribellopora* occurs in an Eocene outcrop at Alma, near Oamaru, South Island, New Zealand (DPG, pers. obs.). The earliest records from the published literature are of *Cribellopora latigastra* (David, 1949) from the Miocene of Austria and the Rhôpne Valley (David & Pouyet 1974; Cook 1985) and *Phonicosia circinata* (MacGillivray 1869) from the Pliocene near Waipukurau, North Island, New Zealand (Brown 1952, as *Arthropoma circinatum*).

ACKNOWLEDGMENTS

We should like to express our thanks to the following: Dr P. J. Chimonides, Natural History Museum, London, for scanning the holotype specimen of *Schizoporella insignis* and sending the photographs for examination; Dr P. J. Hayward, University College of Swansea, for commenting on a draft; Ms Diana Jones, Western Australian Museum, for courtesies extended to S.A.P. during his visit to that institution in November 1991 and for subsequently permitting the loan of the WAM *Vitrius* to D.P.G.; Dr H. B. Womersley, State Herbarium of South Australia, for identifying the substrates of the Australian specimens; and Mr T. Stranks, Museum of Victoria, for information on collections in his care.

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THE LIFE OF A 'MUSEUM MAN' – EDGAR WAITE'S DIARIES AS AN HISTORICAL SOURCE

PHILIP JONES

Summary

The history of science in Australian museums is a relatively new field. While each of the major metropolitan museums in this country has had its own history published, these accounts have tended to be structured around institutions and personalities, rather than the development of Australian science itself. The gap has been filled to some extent by honours theses and articles published during the 1980s and by the survey works of Home (1988) and Moyal (1976). The history of institutional natural science in South Australia has been summarised by Twidale et al (1986). The most detailed analysis of the history of science in Australian museums has been undertaken by the American historian, S. Kohlstedt. She has surveyed the rich historical materials available in Australian natural history museums and has noted the wealth of primary sources available, ranging from committee reports and scientific manuscripts to correspondence files and memoranda (Kohlstedt 1983, 1984).

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The history of science in Australian museums is a relatively new field. While each of the major metropolitan museums in this country has had its own history published, these accounts have tended to be structured around institutions and personalities, rather than the development of Australian science itself. The gap has been filled to some extent by honours theses and articles published during the 1980s and by the survey works of Home (1988) and Moyal (1976). The history of institutional natural science in South Australia has been summarised by Twidale *et al.* (1986). The most detailed analysis of the history of science in Australian museums has been undertaken by the American historian, S. Kohlstedt. She has surveyed the rich historical materials available in Australian natural history museums and has noted the wealth of primary sources available, ranging from committee reports and scientific manuscripts to correspondence files and memoranda (Kohlstedt 1983, 1984).

Sources for the South Australian Museum's history are as well preserved as those for other Australian museums, contained in the Museum's own archives as well as the State Records repository. Incoming and outgoing correspondence has been retained, particularly from the 1890s onwards, and monthly curators' reports supply vital detail for the earlier period from the opening of the Museum in 1862 until late in the century. These reports, and the Museum Committee's minute books, give an indication of the level of expertise and activity expected of the early Museum Directors. Frederick Waterhouse, for example, combined his skill as a practising naturalist with that of an administrator and an informed advocate on museum practice during the 1860s and 1870s as the Museum struggled to cement its place as an indispensable scientific institution in Adelaide. Edward Stirling (Director from 1888-1913) maintained a prodigious level of activity, publishing on zoological and anthropological subjects, reorganising the Museum's galleries and storage, chairing the Museum Committee meetings, as well as lecturing in physiology at the University of Adelaide. This was not uncommon: the careers of other Australian museum directors such as Gerard Krefft, Frederick McCoy, and Robert Etheridge reflect a similar range of commitment and achievement. It is not surprising to find that these individuals' documentary records consist mainly of their working correspondence and manuscripts, rather than separately maintained journals or notebooks.

Until quite recently, the same was thought to be true of the Yorkshire-born Edgar Ravenswood Waite, who succeeded Edward Stirling as Director of the South Australian Museum in 1913. To the good fortune of museum historians though, Waite's private record of his entire working life in museums has been preserved by his family and has recently become available to historians and scientists. This remarkable source material came to light during research undertaken for Waite's entry in the 'Australian Dictionary of Biography', by John Glover, prior to his retirement as Curator of Fishes at the South Australian Museum. The South Australian Museum already holds a large quantity of Waite's professional correspondence, ledgers containing a record of his voluminous scientific and journalistic publications, and several hundred of his photographs.

Waite's diaries cover not only his South Australian Museum directorship (1913-1928), but also document his career from 1888-1893 as Assistant Curator and Curator of the Leeds Philosophical and Literary Society (later Leeds City Museum), as Assistant Curator in charge of vertebrates at the Australian Museum in Sydney (1893-1905), and as Curator of the Canterbury Museum in Christchurch, New Zealand (1905-1913). Six volumes of the complete set of 77 diaries are missing at the time of writing, but may well be located among family members. The diaries have been lodged by the Waite family with the South Australian Museum for copying, pending their permanent transferral there at a future date. The immediate intention is to have the diaries copied on microfiche, with copies available either in that, or in printed form,

The diaries comprise small black notebooks of about 100 pages. The daily entries, about two pages of Waite's neat ink handwriting, are interspersed with occasional newspaper clippings or an ephemeral document, photograph or sketch. With few exceptions, each day of Waite's working life is recorded in at least cursory detail. Although obviously intended as a personal record, the diaries give little more than an outline of Waite's home life with his wife Rose and their only child, Claude. He devotes more time, in contrast, to recording the vagaries of his succession of Douglas motorbikes, which served him well for many years despite scrapes and mishaps. Waite's hobbies as a flautist, photographer and aquarium keeper lend further colour.

While the diaries are generally written with the detachment of an Edwardian scientist, Waite gives occasional vent to the frustrations and rewards of his special position in Adelaide's scientific and cultural life. As with other museum directors, his relationship with members of his controlling committee was not always smooth. Despite this, he had little difficulty in adjusting to his successive working environments. As his biographer, John Glover (1990), has written:

> Imposing but gentle, with a dry sense of humour, he was held in affection and esteem by all who knew him well. ['Australian Dictionary of Biography', vol. 12: 349]

The diaries record some important successes in Waite's negotiations with the Museum Committee, such as their approval (in September 1917) of his suggestion to launch the *Records of the South Australian Museum.*

Waite published a greater range and number of scientific papers than any of his Australian counterparts: a total of 175 papers on Australian and New Zealand subjects during the 35 years from his arrival in Sydney until his death. This number of publications reflects Waite's broad interest in the taxonomy of zoological species. Some of the publications, such as 'The Fishes of South Australia' (Adelaide, 1923) or 'The Reptiles and Amphibians of South Australia' (Adelaide, 1929), remained standard texts for many years.

It might be expected that Waite's diaries would add little to the record of his scientific achievements, and that their primary value to historians might lie only in their anecdotal interest. Certainly this may apply to aspects of Waite's natural science research and collecting activities, such as the fundamental details of the place, date and circumstances of collection. Nevertheless, Waite's succinct first-hand accounts supply an historical depth, otherwise unobtainable, to each of his scientific excursions – ranging from his role on Sir Douglas Mawson's first sub-Antarctic cruise in 1912, his retrieval of whale skeletons and dredging excursions in South Australian waters, to his leadership of the South Australian Museum's collecting expeditions to the north-east of the state in 1916 and to New Guinea, New Britain and New Ireland in 1918.

The ethnographic detail contained in these diaries provides an exciting new insight into the South Australian Museum's anthropological history. Waite's leadership of the 1916 Strzelecki Creek expedition and the 1918 North-West Pacific Islands expedition gave him an opportunity to extend his expertise even further than his broad base in natural science. The 1916 expedition allowed only passing contact with Aboriginal people and Waite's published comment, that 'there is little of interest to write about the aboriginals', might suggest that he had exhausted his potential as an ethnographer. In contrast though, Waite's 1918 expedition to the Pacific yielded almost six tons of natural science and ethnographic specimens. Hale's published history of the South Australian Museum (1956) is vague as to the exact reasons for this expedition, referring only to the fact that Australia's occupation of captured German territory in the Pacific made such an expedition possible. Waite's diary entry for 1 May, 1918, makes Sir Edward Stirling's contribution more apparent:

> Stirling has been very keen on getting Ethnological material from (late) German Territory & he proposed an expedition to New Guinea, New Britain & Solomons. This was agreed to: the director & A.C Davis, late administrator of the natives in New Ireland, to form the party. If the Board approves, I am likely to realise one of my most fervent dreams; to visit the land of the Bird of Paradise & other groups I had not dared to dream of . . .

Waite and Davis made extensive collections of natural history on this expedition, which travelled through Papua New Guinea, New Britain, New Ireland and nearby islands from 31 May to 1 September, 1918. While he paid only brief attention to the structures of social life and ritual, Waite nevertheless distinguished himself as a careful recorder of ethnographic detail. His brief account of the use of a spiders' web net for fishing, on the small island of Mapua, provides an example:

> . . . the web is carried wound across the limbs of a forked stick & when used is unwound & attached to a line like a bait: the teeth of the fish are entangled in the web. As far as I could make out it is garfish that are taken this way (16 July 1918).

Waite and Davis carefully labelled each of their purchases and specimens as they were obtained, and most of these details were subsequently transferred to the South Australian Museum's Anthropology and Natural Science Registers. Additional information may be gleaned from the diaries, nevertheless. This may range from specific detail, such as prices paid for a shark float (two pounds) and a pig net (one pound) in a remote New Ireland village on 8 July 1918, to the anecdotal: on the island of Tabar, Waite became known as 'master belong firewood', for his acquisition of funerary malanggan masks which would ordinarily have been burnt (9 August 1918). The background to these ethnographic transactions is crucial to an adequate understanding of the artefacts, many of which have been on display in the Museum's Pacific Gallery or in storage for the past seven decades.

Like his predecessor at the South Australian Museum, Edward Stirling, Waite possessed the facility of making useful contacts wherever he travelled. Although he and Davis each made sizeable ethnographic collections on this expedition, these were outnumbered by others which Waite was able to purchase from other individuals such as Whiteman, Hunter, Cummins, Eugelke, Goedecke-Meyer, Petterson and Gotham, who had established themselves as traders and officials throughout the region. These transactions, as well as individual purchases and exchanges with native people, are all recorded in the diaries.

The discovery of a previously unknown or unused primary historical source is always an exciting event, not least for the light which it may cast, in turn, on other documentation. In Waite's case, it will enable a thorough attempt to be made at cataloguing his extensive collection of photographs, already held in the

South Australian Museum. These depict many aspects of his museum career, particularly field expeditions. More generally though, the Waite diaries provide an opportunity for the re-evaluation of the place of Australian and New Zealand museums within their local scientific and cultural milieu, at a time when colonial science was strongly asserting itself in relation to its British and European origins.

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RECORDS OF THE SOUTH AUSTRALIAN MUSEUM

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FIRST REPORT OF THE ENIGMATIC METAZOAN ANOMALOCARIS FROM THE SOUTHERN HEMISPHERE AND A TRILOBITE WITH PRESERVED APPENDAGES FROM THE EARLY CAMBRIAN OF KANGAROO ISLAND, SOUTH AUSTRALIA

B. McHenry & A. Yates

Summary

Recently discovered fossils from the Early Cambrian, Emu Bay Shale of Kangaroo Island include a new and undescribed species of the enigmatic metazoan Anomalocaris Whiteaves, 1892, and a cephalon with preserved antennae of the trilobite Redlichia takooensis Lu, 1950. The site is recognised as the first occurrence of Anomalocaris in the southern hemisphere and the discovery of this animal supplies a possible predator capable of inflicting injuries to the large trilobites reported from the locality. The trilobite specimen is not only the first from Australia with preserved appendages but is the only redlichiid known to exhibit this feature.

FIRST REPORT OF THE ENIGMATIC METAZOAN *ANOMALOCARIS* FROM THE SOUTHERN HEMISPHERE AND A TRILOBITE WITH PRESERVED APPENDAGES FROM THE EARLY CAMBRIAN OF KANGAROO ISLAND, SOUTH AUSTRALIA

B. MCHENRY & A. YATES

MCHENRY, B. & YATES, A. 1993. First report of the enigmatic metazoan *Anomalocaris* from the southern hemisphere and a trilobite with preserved appendages from the Early Cambrian of Kangaroo Island, South Australia. *Rec. S. Aust. Mus.* **26**(2): 77–86.

Recently discovered fossils from the Early Cambrian, Emu Bay Shale of Kangaroo Island include a new and undescribed species of the enigmatic metazoan *Anomalocaris* Whiteaves, 1892, and a cephalon with preserved antennae of the trilobite *Redlichia takooensis* Lu, 1950. The site is recognised as the first occurrence of *Anomalocaris* in the southern hemisphere and the discovery of this animal supplies a possible predator capable of inflicting injuries to the large trilobites reported from the locality. The trilobite specimen is not only the first from Australia with preserved appendages but is the only redlichiid known to exhibit this feature.

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Enigmatic 'soft-bodied' faunas have been reported from many Cambrian localities (Conway Morris 1989). Exceptionally well preserved fossils occur in the lower part of the Early Cambrian Emu Bay Shale, exposed East of the mouth of Big Gully, 3km West of White Point on the northern coast of Kangaroo Island, South Australia (see Fig. 1). At this site lightly skeletonised and soft parts are presumed to be preserved as sheets of fibrous calcite (Glaessner 1979) although they have never been analysed. The fauna described so far from this locality consists of the annelid worms *Paleoscolex antiquus* Glaessner 1979, *Myoscolex ateles* Glaessner 1979 and *Vestustivermis planus* Glaessner 1979, the trilobites *Hsuaspis bilobata* (Pocock 1964) and *Redlichia takooensis* Lu 1950 and the possible phyllocarid crustaceans *Isoxys communis* Glaessner 1979 and *Tuzoia australis* Glaessner 1979. The Emu Bay Shale and its fauna have been suggested to be an approximate equivalent to the *Pararaia janeae* trilobite zone of the South Australian Cambrian sequence. Although correlations between the Cambrian sequences of Australia and the rest of the world are not easy, it has been tentatively assigned on the basis of trilobites, archaeocyatha, molluscs and 'small shelly' fossils to the Late Botomian Stage of the Siberian Scale for the Early Cambrian (520–530 Myr BP) (Bengston *et al.* 1990).

Reports of indiscriminate and destructive excavation at this site by commercial collectors in early 1991 prompted an examination by one of us (A.Y.), to assess the amount of material removed and to make a representative collection for the South Australian Museum. Among the important discoveries made during this field trip were that of remains of what

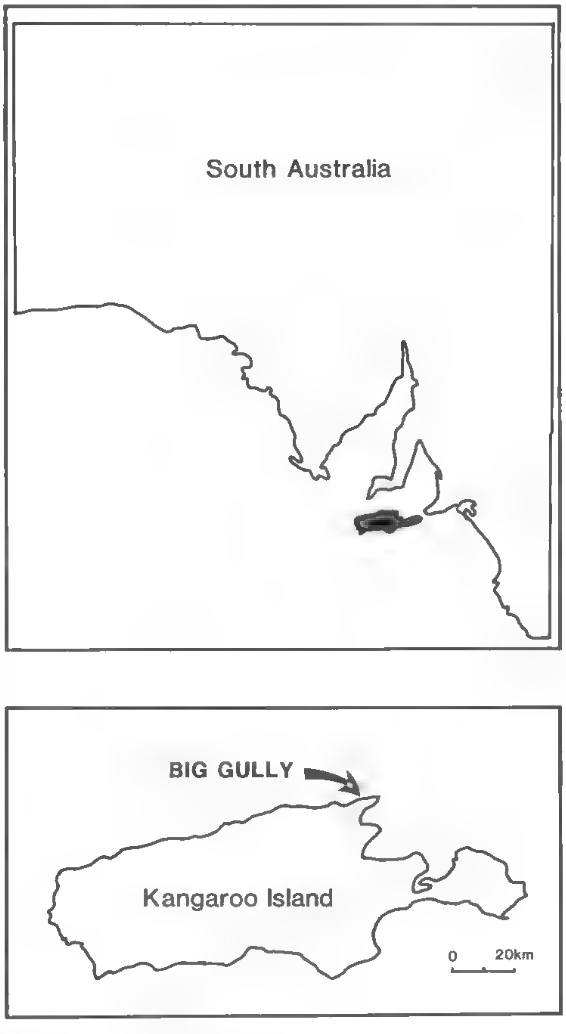

FIGURE 1. Locality maps.

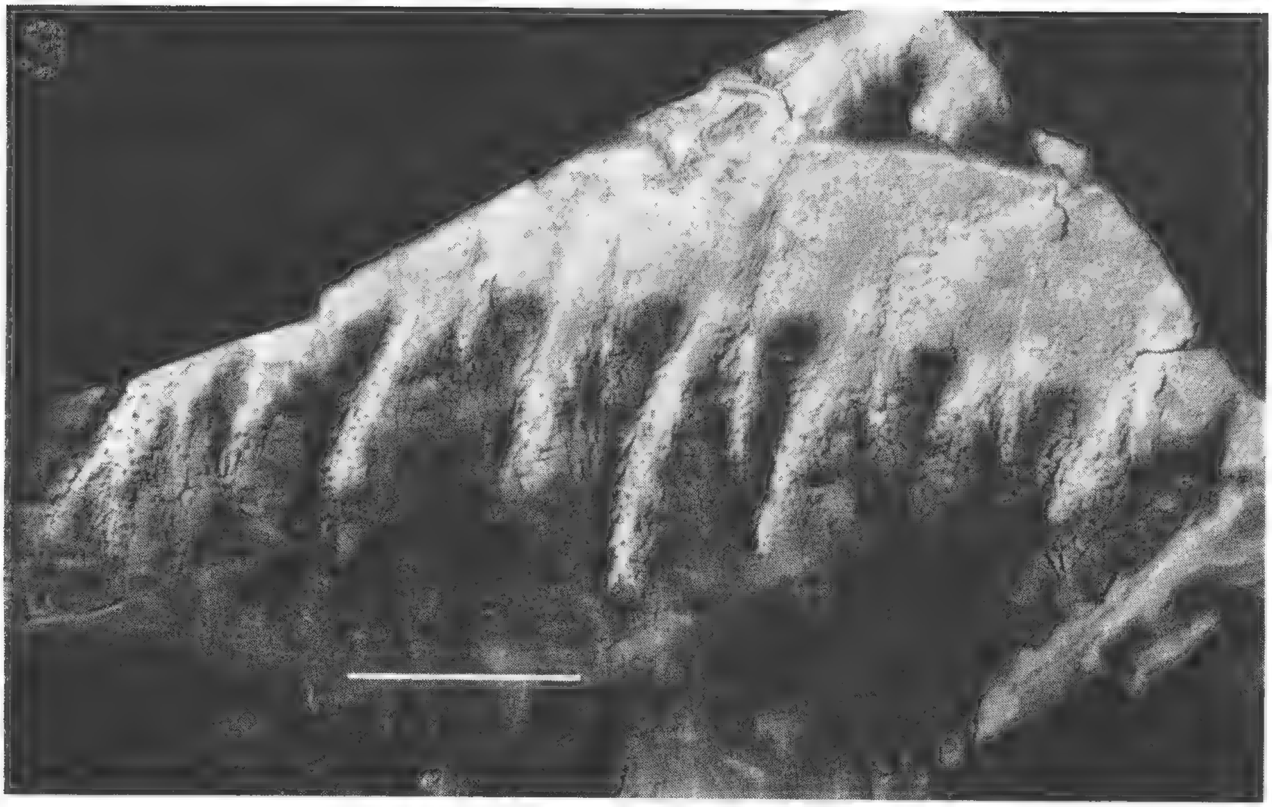

FIGURE 2. Cephalic appendages of *Anomalocaris* sp. from the Early Cambrian Emu Bay Shale, Big Gully, Kangaroo Island, South Australia (SAM P31953 A and B). Visible are two partial appendages (specimens A and B) with ventral spines extending downwards. A partial cephalon of the trilobite *Hsuaspis bilobata* (Pocock, 1964) is located between the two appendages. Scale bar 20 mm.

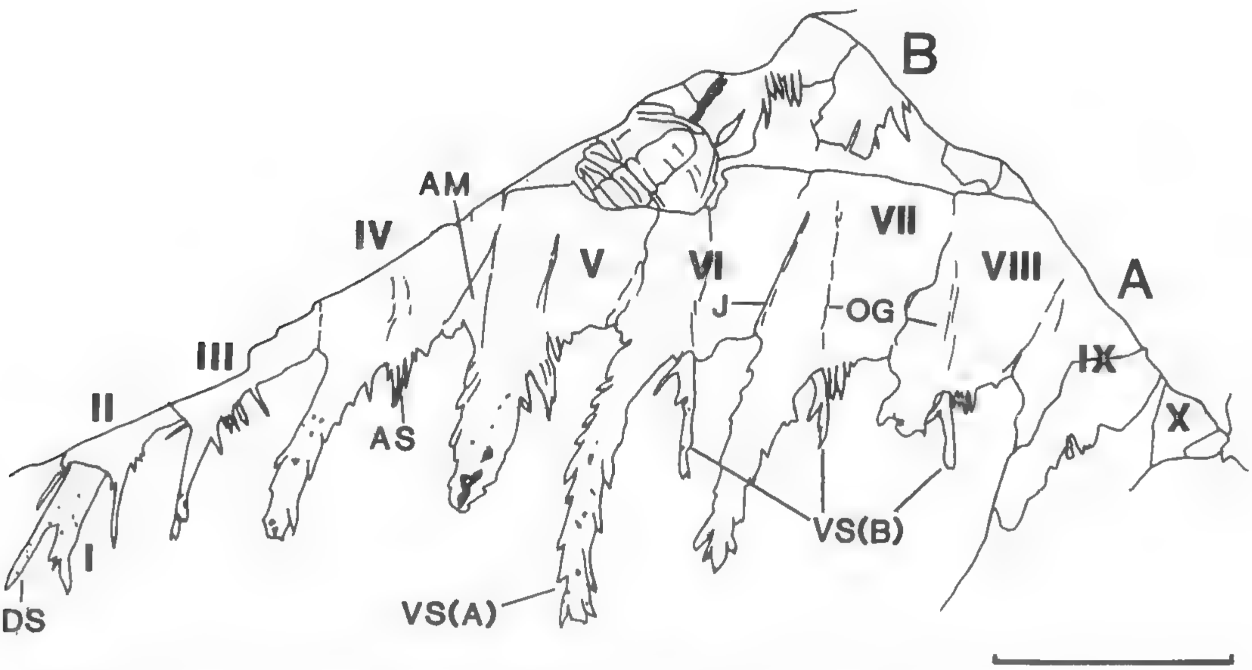

FIGURE 3. Line drawing of cephalic appendages of *Anomalocaris* sp. from Kangaroo Island, same specimens as Figure 2. Segment numbers I - X of specimen A are preserved but the base of the appendage is missing. Only a small fragment of specimen B is visible. The dorsal spine (DS) on specimen A is present as are ventral spines for both specimens, VS(A) and VS(B). Joints between the segments (J) are identifiable as are the 'oblique grooves'(OG) attributed to the crushing of specimen A onto B. Scale bar 20 mm.

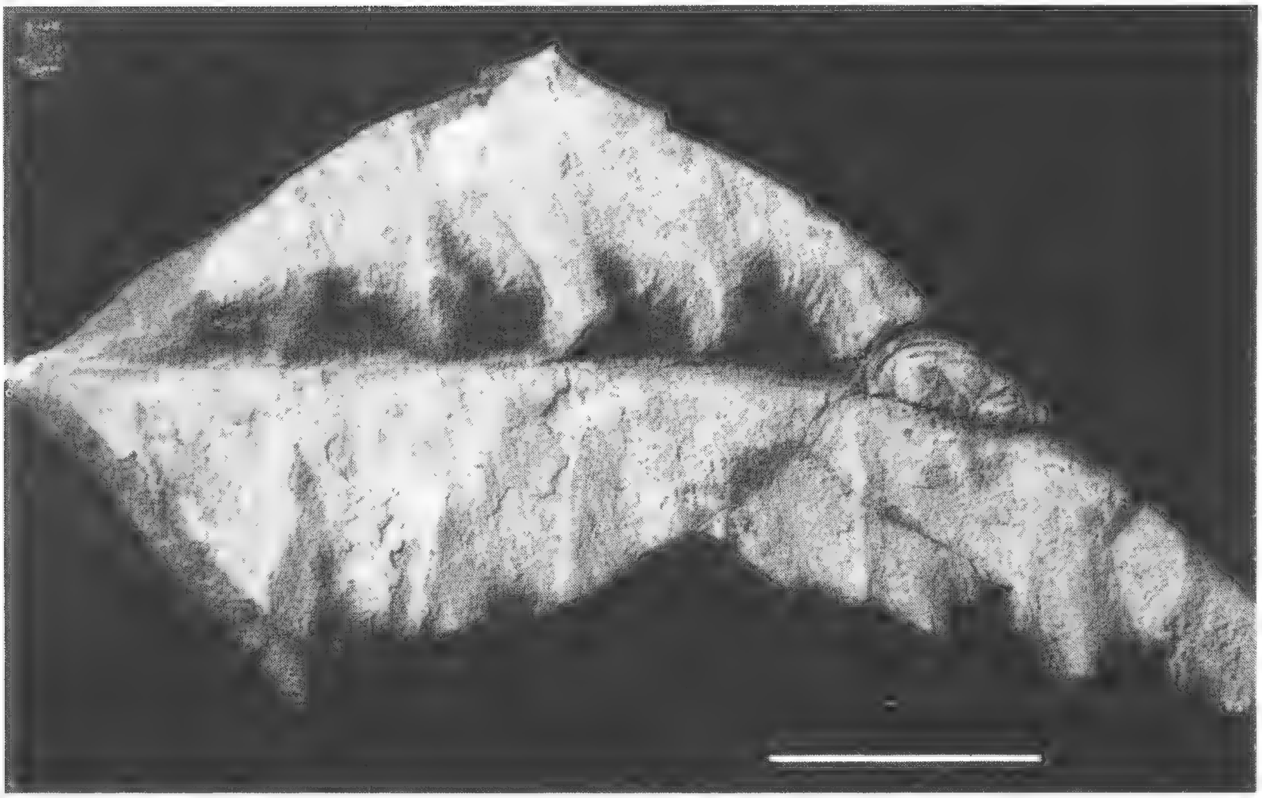

FIGURE 4. Cephalic appendages of *Anomalocaris* sp. from the Early Cambrian Emu Bay Shale, Big Gully, Kangaroo Island, South Australia (SAM P31954 A and B). Counterpart slab of SAM P31953. Visible are two partial appendages (specimens A and B) with ventral spines extending downwards. A partial cephalon of the trilobite *Hsuaspis bilobata* (Pocock, 1964) is located between the two appendages. Scale bar 20 mm.

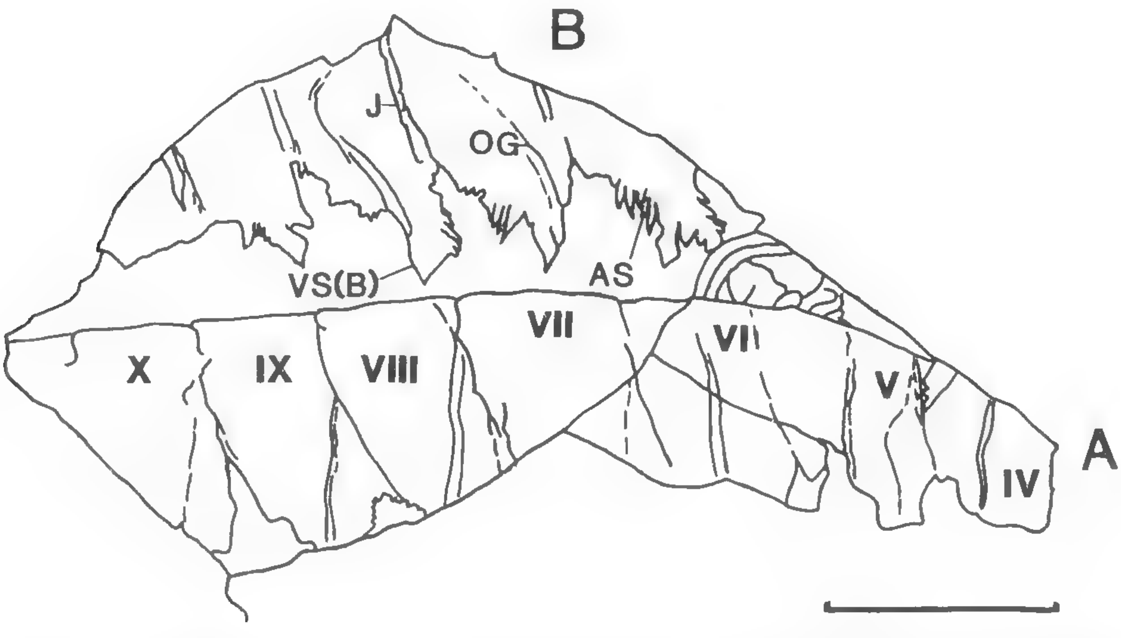

FIGURE 5. Line drawing of cephalic appendages of *Anomalocaris* sp. from Kangaroo Island, same specimens as Figure 4. Segment numbers IV - X of specimen A are preserved but the ventral spines are missing. Specimen B is more completely represented than on SAM P31953 and both the ventral spines, VS(B), and auxiliary spines, AS, are visible. Joints between the segments (J) are also identifiable. Scale bar 20 mm.

FIGURE 6. Partial cephalic appendage of *Anomalocaris* sp. from the Early Cambrian Emu Bay Shale, Big Gully, Kangaroo Island, South Australia (SAM P51955). The small clusters of auxiliary spines which occur at the base of the ventral spines of the appendage and are unique to the Kangaroo Island specimens are clearly visible. Scale bar 20 mm.

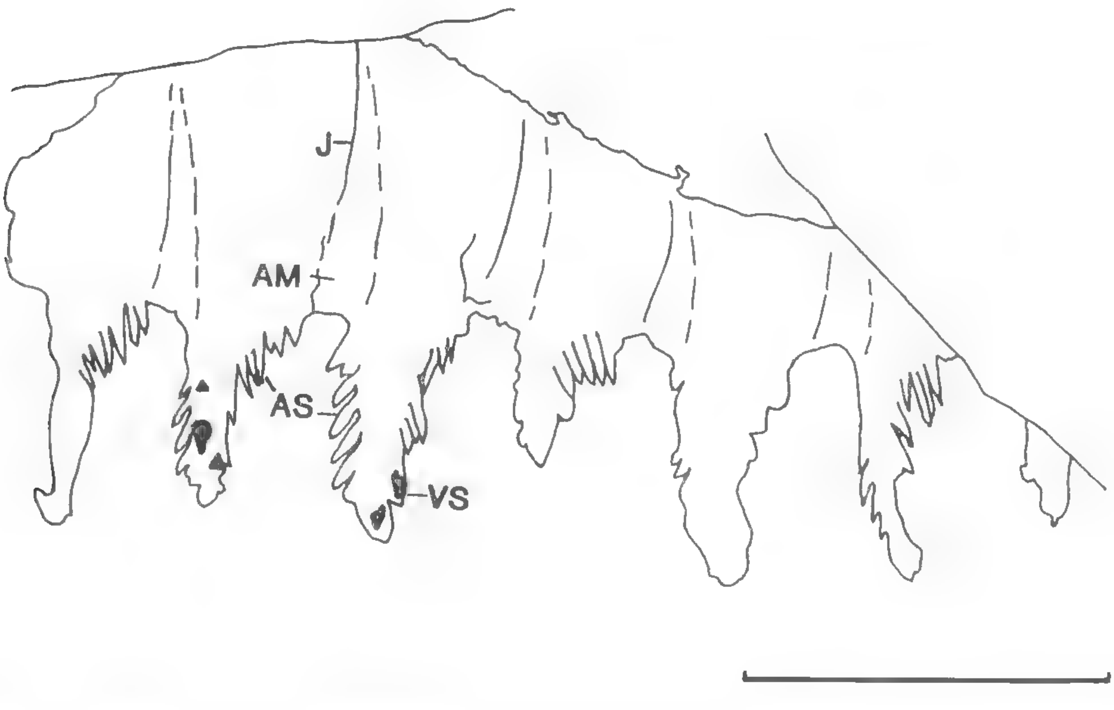

FIGURE 7. Line drawing of partial cephalic appendage of *Anomalocaris* sp. from Kangaroo Island, same specimen as Figure 6. The group of auxilliary spines (AS) at the base of the ventral spines (VS) are indicated, as well as areas of possible arthrodial membrane (AM) at the joints (J) between the segments. Scale bar 20 mm.

appears to be a new species of the enigmatic metazoan *Anomalocaris* Whiteaves, 1892, and a specimen of the trilobite *Redlichia takooensis* Lu, 1950, with preserved appendages.

All specimens were found in loose blocks that had been left by the collectors, so precise stratigraphic information is not yet available. There are two main areas of exposure at the site, one in the sea-cliff and the other on the wave cut platform (Glaessner 1979). The specimens of *Anomalocaris* originated from the wave cut platform while the trilobite specimen cannot be placed as it was part of the previous collectors' discard pile. These specimens are now housed in the palaeontological collections of the South Australian Museum (SAM P31953–P31957). Here we report and briefly describe these new specimens. Detailed descriptions of the species are the subject of current research and will be published in the future.

Description Of Material

Anomalocaris sp.

The first specimens to be reported in Australia of *Anomalocaris* are three large curving, segmented cephalic appendages. These appear to belong to an as yet unnamed species. They occur on three slabs (SAM P31953, P31954, P31955 (Figs 2–7), the first two slabs being a part and counterpart set. The more complete specimens are two appendages lying parallel and partly overlapping each other and occur on the part/counterpart slabs (P31953A and B, P31954A and B (Figs 2, 4). The other specimen (P31955) is a single fragment of a lone appendage (Fig. 6). The most complete specimen measures 107 mm in length and 19 mm in width at the proximal end, tapering to a point distally (Figs 2, 3). This appendage has the remains of 10 preserved segments including the terminus, but is incomplete and almost certainly possessed more segments as in other anomalocarids. In this description, because preservation is incomplete, segments on the appendages have been numbered from the terminus for expediency. Thus the terminating segment has been numbered I, the penultimate II, and so on. Each segment bears ventrally at its distal end a long proximally curving spine with the most complete one preserved (on segment VI of P31953A) being 3 mm wide and 26 mm long, which is longer than the appendage is deep (Figs 2, 3). There is no evidence that these ventral spines were paired. The smaller spines seen lying along the ventral spines of segments VI–VIII of P31953A are the tips of the ventral spines of P31953B (Figs 2, 3).

The ventral spines bear many (between 1 and 9) small auxiliary spines of approximately 1–2 mm in length, particularly along their distal borders although the actual numbers of these auxiliaries present is probably a product of preservation. On the proximal side of the base of the main spines, there is a group of approximately 4 closely spaced auxiliary spines 3–4 mm long. These are present on all specimens but are particularly well preserved on the first two ventral spines of P31955 (Figs 6, 7).

Single dorsal spines, 8 mm in length, are present on segments I and II of P31953A (Figs 2, 3). The dorsal area of segments III and IV is missing whereas the dorsum of all other segments is smooth and lacking any spines. The fibrous calcite sheet is noticeably thinner around the ventral segment boundaries. This is reflected by a reddish colouration in P31955 and is thought to possibly represent areas of arthrodial membrane previously described in specimens of *A. canadensis* (Briggs 1979) (Figs 6, 7). Oblique grooves can be seen to run through the segments of both appendages on P31953. Since there are none of these grooves present on P31955, they are thought to represent post mortem features created by compaction: at least some of the grooves on P31953A are attributable to the appendage being crushed into the underlying spines of P31953B (Figs 2, 3).

Mention should be made of a problematic radially lobate fossil collected with the *Anomalocaris* material (SAM P31956 (Fig. 8). This specimen does bear some resemblance (though perhaps superficially) to the mouth of *Anomalocaris* (Fig. 9). In the Burgess Shale the mouth occasionally occurs separately from the anomalocarid body (Whittington & Briggs 1985) and was originally described by Walcott in 1911 as a medusoid, *Peytoia*. As with an *Anomalocaris* mouth, it consists of a series of groups of narrow lobes separated by single wider lobes. Unlike *Anomalocaris*, however, the narrow lobes appear to be transversely ribbed and this form has no central opening. We believe this may be due to the specimen being preserved in a closed state. Whittington & Briggs (1985) have reported the anomalocarid mouth as being recognized in a variety of orientations and states of closure but as this specimen is badly eroded a confident interpretation cannot be made without further material.

Trilobite Appendages

The single specimen of *Redlichia takooensis* Lu, 1950, with preserved appendages (SAM P31957) consists of an obliquely distorted, two thirds of a cephalon that measures 117 mm in width (Figs 10, 11). Protruding from the anterior border of the cephalon are what appear to be two short antennae which are 24 mm and 30 mm in length respectively, tapering from a maximum measured width of 3.5 mm to a point. Segment borders can be seen on the right antenna where the calcite replacement has flaked away leaving a mould (Fig. 12). There appear to be 11–13

FIGURE 8. Possible mouth of *Anomalocaris* sp. from the Early Cambrian Emu Bay Shale, Big Gully, Kangaroo Island, South Australia (SAM P51956). Scale bar 10 mm.

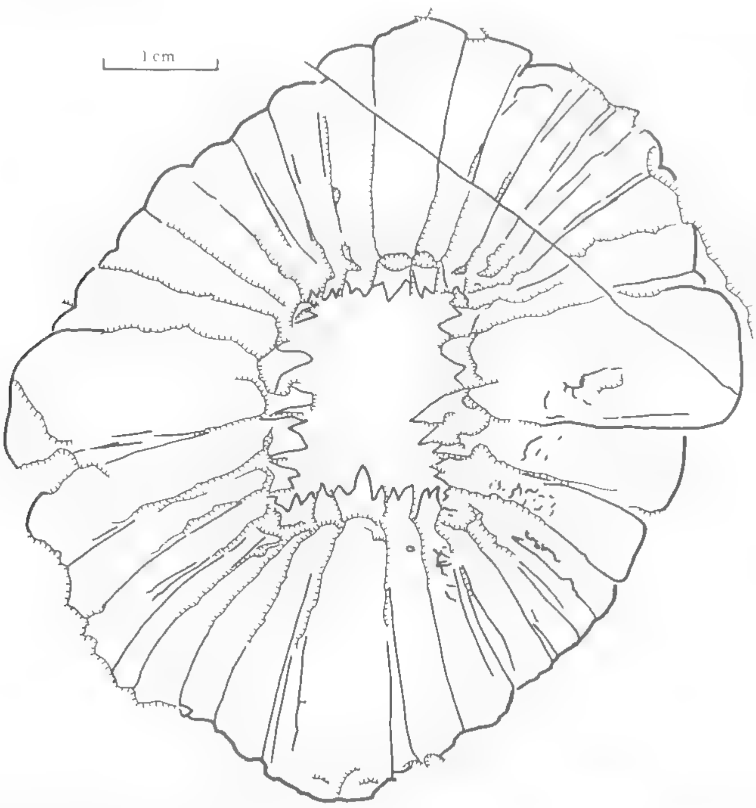

FIGURE 9. Composite drawing of the mouth of holotype of *Anomalocaris nathorsti* (Walcott, 1911) from the Middle Cambrian Burgess Shale 'Phyllopod Bed', Stephen Formation, 4.8 km North of Field, British Columbia (United States National Museum no. 57538). (From Whittington and Briggs 1985, Figure 60).

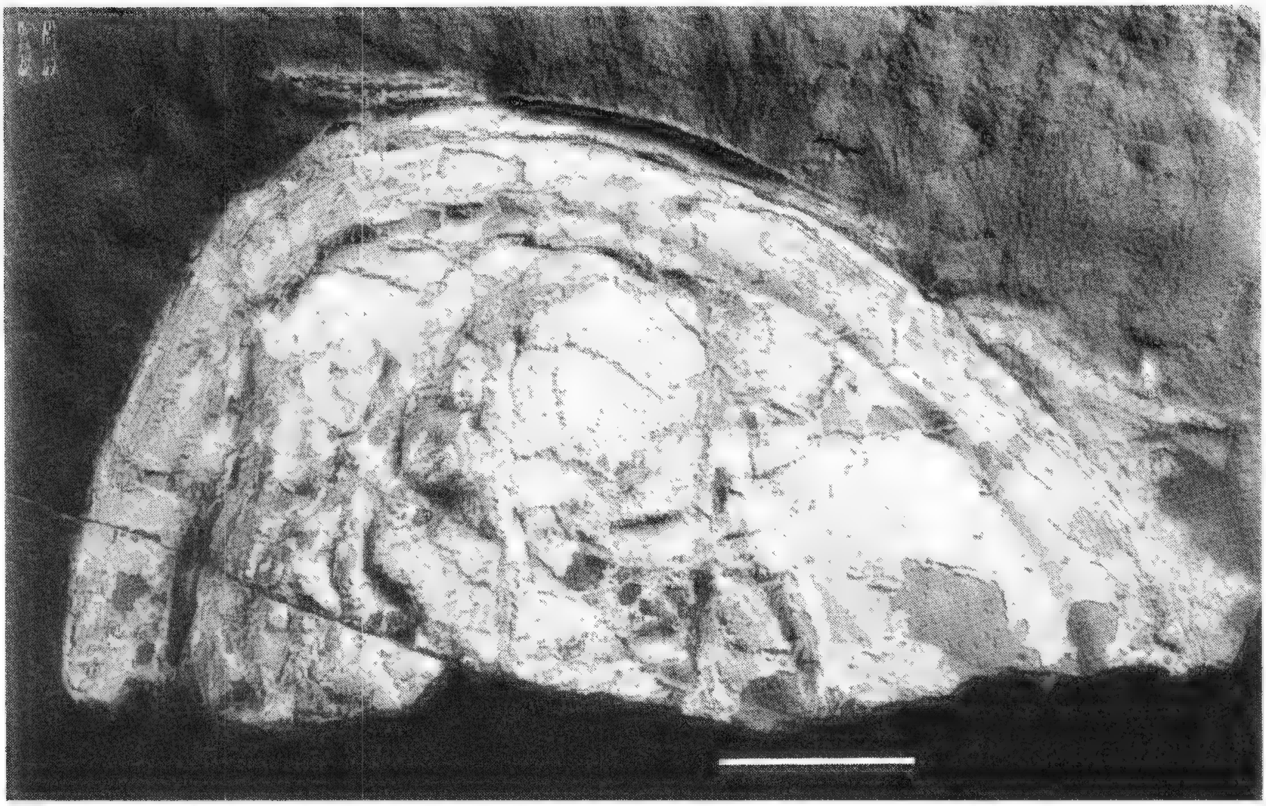

FIGURE 10. Partial cephalon of *Redlichia takooensis* Lu, 1950, from the Early Cambrian Emu Bay Shale, Big Gully, Kangaroo Island, South Australia (SAM P51957). The two segmented antennae can clearly be seen protruding from under the anterior border of the cephalon. Scale bar 20 mm.

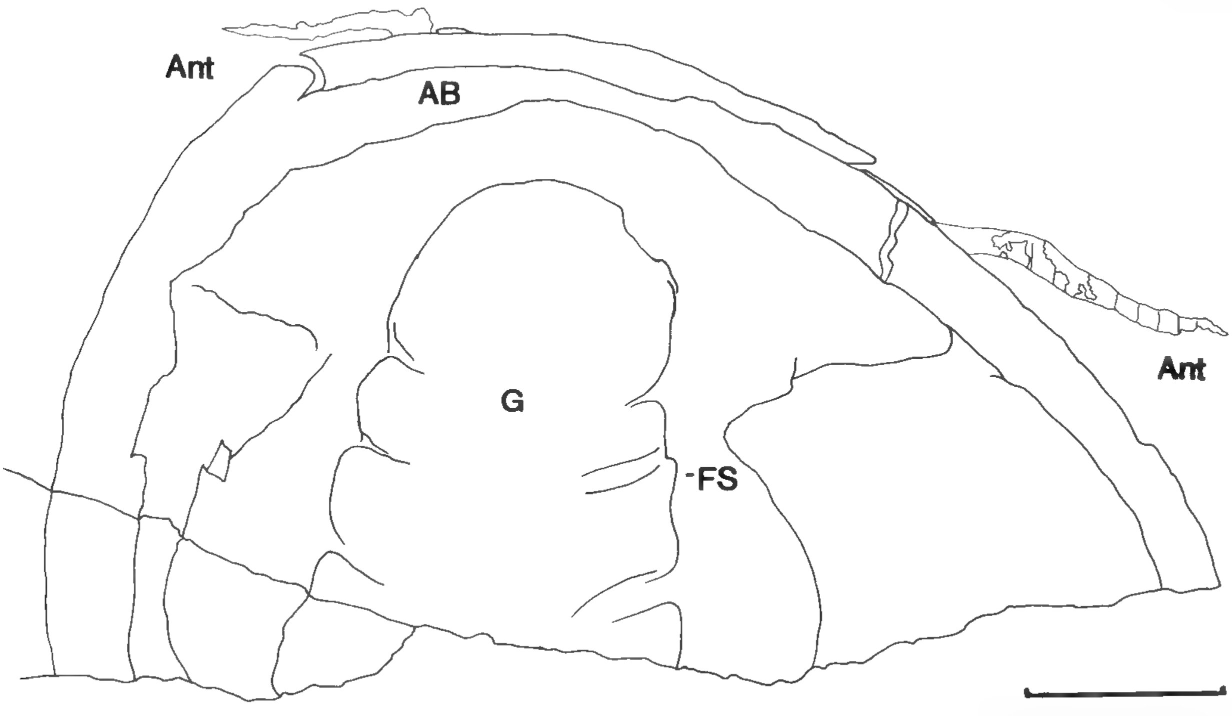

FIGURE 11. Line drawing of partial cephalon of *Redlichia takooensis* Lu, 1950, from Kangaroo Island, same specimen as Figure 10. The anterior border (AB), facial suture (FS) and glabella (G) can be readily delineated as well as the two protruding segmented antennae (ANT). Scale bar 20 mm.

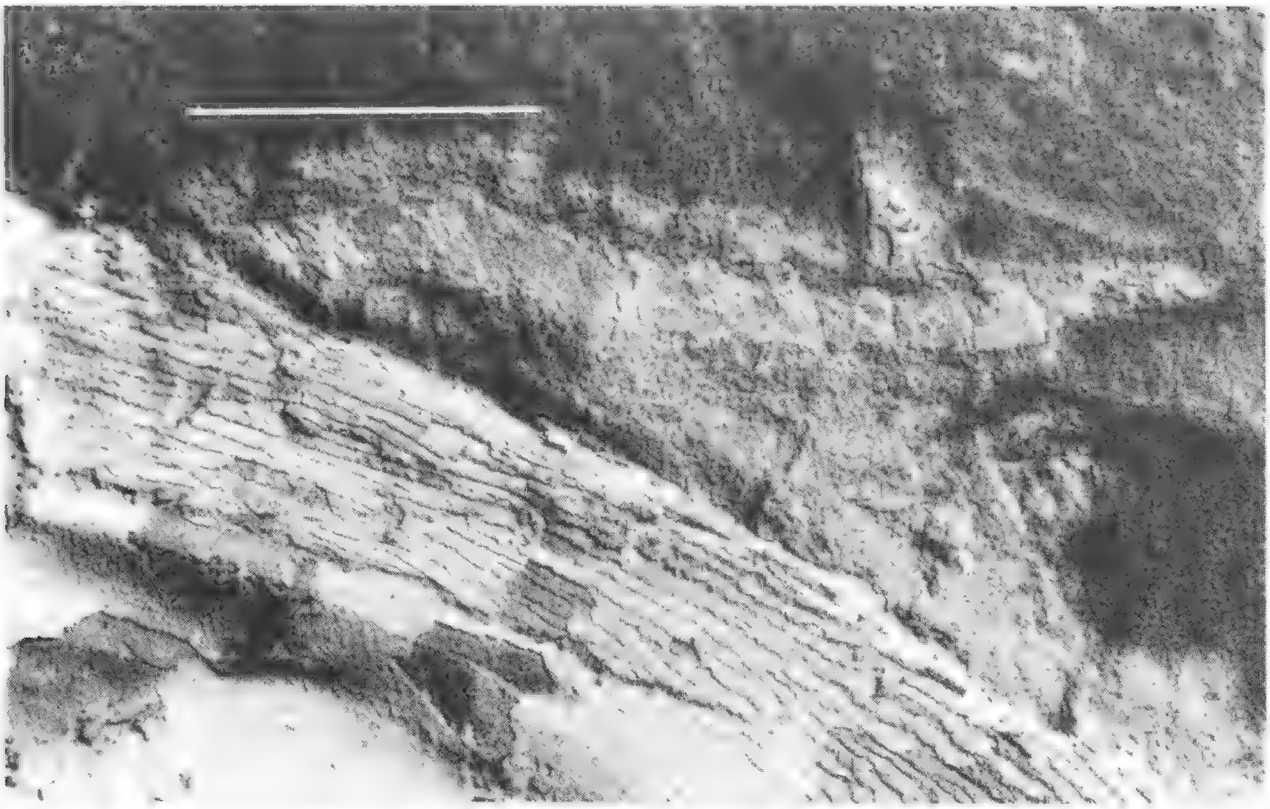

FIGURE 12. Enlargement of anterior border of cephalon of *Redlichia takooensis* Lu, 1950, same specimen as Figure 9, showing right antenna. Scale bar, 10 mm.

segments visible on the section of the antenna which protrudes from under the cephalon (Fig. 11). This is the first known Australian trilobite to have appendages preserved and these are also the first known redlichiid appendages to have been discovered.

Discussion

Our specimens of *Anomalocaris* share some characteristics with *A. canadensis* Whiteaves 1892 and some with *A. nathorsti* (Walcott 1911) but also possess features not found in the described species of this genus. As in *A. canadensis* there are no lateral spines, the dorsal spines are restricted to the terminal segments and the cephalic appendage is not strongly recurved. *Anomalocaris nathorsti* has unpaired ventral spines which are longer than the segments are deep and possesses numerous small auxiliary spines which do not alternate in length. The group of auxiliary spines occurring at the base of the main ventral spines is unique to the South Australian species.

Anomalocaris has been interpreted as a large Cambrian predator (Whittington & Briggs 1985, Briggs & Whittington 1985) although the theory has been raised that some anomalocarids may have been filter feeders. Forms such as *A. nathorsti* and *Cassubia infercambriensis* (Lendzion 1975) possess broad, blade-like spines which contact each other and form a graticule, suggestive of an arrangement analogous to the filtratory feeding appendages of some living crustaceans (Dzik & Lendzion 1988). To our knowledge the species from Kangaroo Island is similar to *A. canadensis* and *A. pennsylvanicus* Resser, 1929, and does not have this arrangement of spines. It therefore should not be included amongst the possible detrital feeders.

Except for the articulated material in the Burgess Shale (Whittington & Briggs 1985) and a single other specimen (Briggs & Robison 1984), remains of *Anomalocaris* occur only as isolated appendages. Anomalocarids have been reported from the Early Cambrian of British Columbia (Resser 1929, Briggs 1979), Pennsylvania (Resser & Howell 1938, Briggs 1978), California (Mount 1974, Briggs & Mount 1982), NE Poland (Dzik & Lendzion 1988), southern China (Chen *et al.* 1991, Hou & Bergstrom 1991), and from the Middle Cambrian of Utah (Briggs & Robison 1984, Conway Morris & Robison 1982, 1986, 1988) and several localities in British Columbia (Fritz 1971, Collins *et al.* 1983, Whittington & Briggs 1985). The discovery of the Kangaroo Island specimens extends the range of this group of animals to the current southern hemisphere, showing that they had a worldwide distribution in the Early Cambrian (Fig. 13).

Reported specimens of redlichiid trilobites from the Emu Bay Shale possess what appear to be healed injuries which had been inflicted by an unknown

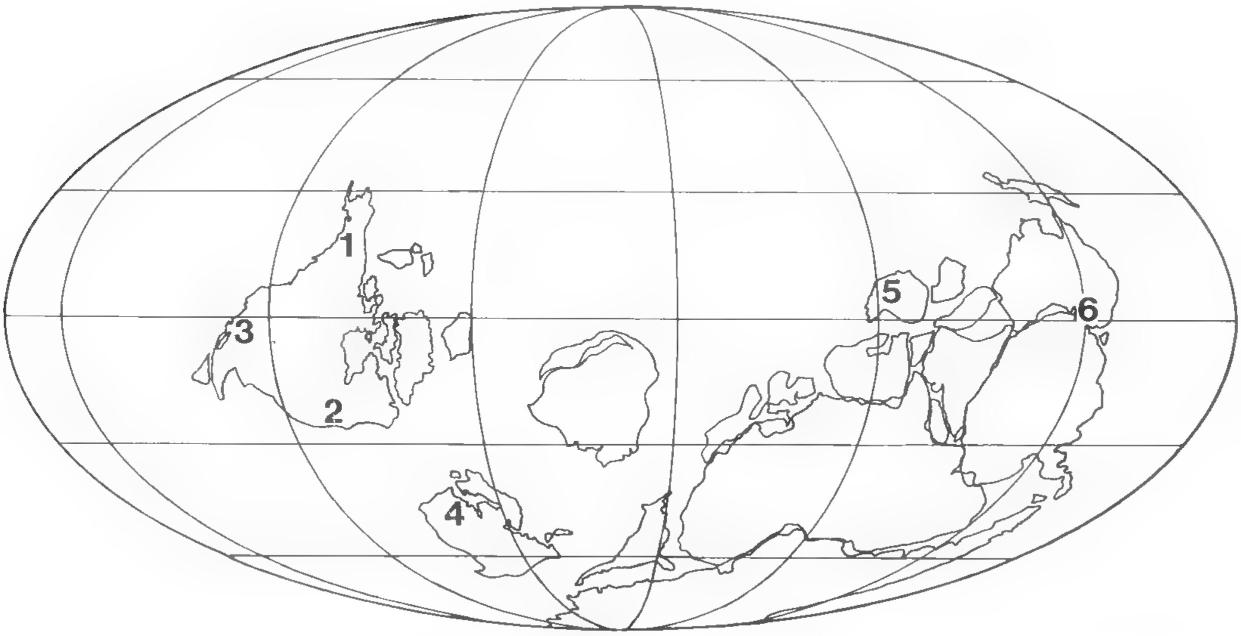

FIGURE 13. Reconstruction of continental positions during Early Cambrian (520–530 Myr BP; after McKerrow *et. al.* 1992) showing known occurrences of *Anomalocaris*. 1, British Columbia; 2, Pennsylvania; 3, California; 4, NE Poland; 5, Southern China; 6, South Australia (see text).

predator (Conway Morris & Jenkins 1985). It was concluded that the predator might have been an undiscovered metazoan or that the trilobites might have been cannibalistic. We consider it to be very probable that at least some of these injuries might have been inflicted by *Anomalocaris* sp., an occurrence that has been suggested by similar marks found on trilobites from the Middle Cambrian Burgess Shale locality at Mount Stephen in Canada (Rudkin 1979, Whittington & Briggs 1985, Briggs & Whittington 1985), middle Cambrian strata in Utah (Vorwald 1982) and the lower Cambrian of California (Alpert & Moore 1975). The healed injuries on the Kangaroo Island specimens include missing pleural tips as well as excisions into the distal portions of the pleura. Whittington & Briggs (1985) suggested that *Anomalocaris* most probably fed by capturing prey with the cephalic appendages and then used these to draw the food to the ventrally placed mouth. It is possible that the observed injuries in the Kangaroo Island redlichiids represent the results of an unsuccessful attack by an anomalocarid attempting to bite a struggling trilobite, which was rewarded for its efforts by eventual escape from the grasp of the predator's cephalic appendages.

These newly reported fossil specimens suggest that the South Australian locality bears a closer resemblance to the famous Burgess Shale of British Columbia than was previously recognised. Further studies at this site will contribute to an understanding of how these exceptional preservations have occurred and help shed some light on the current problems associated with interpreting this world-wide fauna (Gee, 1992).

Acknowledgments

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MOLLUSC TYPE SPECIMENS IN THE SOUTH AUSTRALIAN MUSEUM. 5. GASTROPODA : CYPRAEOIDEA

K. L. Gowlett-holmes & W. Zeidler

Summary

The South Australian Museum collection of Cypraeoidea types contains 66 species, subspecies or varieties of the families Cypraeidae (55 taxa), Ovulidae (3 taxa) and Triviidae (8 taxa). Most of these are foreign, with 34 from Fiji alone, three from New Caledonia, two from the Hawaiian Islands and one taxon each from Borneo, Madagascar, Paua New Guinea and Timor. The 17 Australian taxa are from Western Australia and South Australia. Six taxa are without any locality data.

MOLLUSC TYPE SPECIMENS IN THE SOUTH AUSTRALIAN MUSEUM. 5. GASTROPODA: CYPRAEOIDEA

K. L. GOWLETT-HOLMES & W. ZEIDLER

GOWLETT-HOLMES, K. L. & ZEIDLER, W. 1993. Mollusc type specimens in the South Australian Museum. 5. Gastropoda: Cypraeoidea. *Rec. S. Aust. Mus.* **26**(2): 87–103

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The following catalogue of type specimens of the superfamily Cypraeoidea held in the South Australian Museum (SAM) is part of an ongoing program to provide such information as an aid to future taxonomic studies.

The South Australian Museum's collection of Cypraeoidea has been acquired by a variety of means. The bulk of the historical material was collected, or otherwise obtained, by Sir Joseph Verco around the turn of the century. As cowries and their allies have always been very collectable items, many additions have been made to the collections by donation or by purchasing other peoples' collections. One of the most significant of these was the A. F. Kenyon Collection, which the Museum purchased early this century. Mrs Kenyon accumulated a relatively large collection and acquired many types, particularly of cowries and cones. Cowries were her special interest, and she described a number of new species and varieties, the types of which are represented in the collections, although none of these species are now considered valid. Apart from Kenyon (1897, 1898, 1900 & 1902), the other major addition to the type collection was by Steadman and Cotton (1943, 1946), who described a number of varieties and subspecies, mainly from Fiji, only one of which may now be valid.

The Cypraeoidea type collection represents 66 species, subspecies or varieties of the families Cypraeidae (55 taxa), Ovulidae (3 taxa) and Triviidae (8 taxa). Most of these are foreign, with 34 from Fiji alone. Other foreign specimens are from Borneo (1), Hawaiian Islands (2), Madagascar (1), New Caledonia (3), Papua New Guinea (1) and Timor (1). Australian specimens are from Western Australia (W.A.) (11) and South Australia (S.A.) (6). Six taxa are without any locality data. All of the types except for some paratypes of *Crenavolva cruenta* Gowlett-Holmes & Holmes, 1989, are dry and in most cases are only represented by the shell.

In the following list, species are listed alphabetically according to their names at the time of description. Current synonymies are according to Burgess (1985) for the Cypraeidae, Cate (1973) for the Ovulidae, and Cate (1979) for the Triviidae, unless otherwise noted. Higher classification is according to Vaught (1989).

Some of the early mollusc taxonomists did not indicate type specimens and often their descriptions were based on more than one specimen. In those cases where no holotype was designated and the description was clearly based on more than one specimen, the type series held in SAM is considered syntypic (Article 73(b), ICZN). Where the description was clearly based on a single specimen, this specimen is considered to be a holotype, even if it was not clearly designated as such (Article 73(a), ICZN).

We have illustrated selected taxa, mainly those which have not been illustrated adequately previously, or were not listed by Burgess (1985), or those whose present taxonomic status is doubtful

Superfamily CYPRAEOIDEA

Family CYPRAEIDAE

Genus *Arabica* Jousseaume, 1884

Arabica eglantina momokiti Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 327.
= *Cypraea eglantina* Duclos, 1833.
Holotype: D14162, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention numerous specimens from Suva and Nadroga, but did not designate any paratypes.

Arabica scurra vono Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 328.
= *Cypraea scurra* Gmelin, 1791.
Holotype: D14163, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention a further eleven specimens from Suva and Nadroga, but did not designate any paratypes.

Genus *Basilitrona* Iredale, 1930

Basilitrona isabella cavia Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 326.
= *Cypraea isabella* Linnaeus, 1758.
Holotype: D14161, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention numerous specimens from Suva and Nadroga, but did not designate any paratypes.

Basilitrona isabella lemuriana Steadman & Cotton, 1946
Rec. S. Aust. Mus. **8**(3): 507.
= *Cypraea isabella* Linnaeus, 1758.
Holotype: D14516, adult specimen, from Madagascar, collector and date of collection unknown.

Genus *Bistolida* Cossman, 1920

Bistolida fluctuans nandronga Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 318–9.
= *Cypraea stolida* Linnaeus, 1758.
Holotype: D14148, adult specimen, from Nadroga, Fiji, collected by W. R. Steadman, date of collection unknown.

Bistolida stolida thakau Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 318.
= *Cypraea stolida* Linnaeus, 1758.
Holotype: D14147, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.

Genus *Blasicrura* Iredale, 1930

Blasicrura rhinoceros vivia Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 323.
= *Cypraea pallidula* Gaskoin, 1849.
Holotype: D14157, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention numerous specimens from Suva and Nadroga, but did not designate any paratypes.

Genus *Callistocypraea* Schilder, 1927

Callistocypraea aurantium turanga Steadman & Cotton, 1943.
Rec. S. Aust. Mus. 7(4): 329–30.
= *Cypraea aurantium* Gmelin, 1791.
Holotype: D14165, adult specimen, from Nadroga Fiji, collector and date of collection unknown.
Note: Steadman and Cotton (1943) mention a further twelve specimens obtained from Fijian natives at Nadroga, but did not designate any paratypes.

Genus *Cribraria* Jousseaume, 1884

Cribraria cribraria northi Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 318.
= *Cypraea cribraria* Linnaeus, 1758.
Holotype: D14146, adult specimen, from Nadroga, Fiji, collected by W. O. North, date of collection unknown.
Note: Steadman and Cotton (1943) mention a further nineteen specimens from Suva and Nadroga, but did not designate any paratypes.

Cribraria haddnightae Trenberth, 1973
Malac. Soc. S. Aust. Occ. Publ. **17**: no pagination, pls 1,2.
= *Cypraea haddnightae* (Trenberth, 1973).
Holotype: D15132, adult specimen, dead collected, on beach, from Parrys Beach, west of Denmark, near Albany, W. A., collected by F. Haddrill and M. Knight, date of collection unknown.
Note: According to Trenberth (1973), paratypes of this species are in the private collections of Miss F. Haddrill, Miss M. Knight, W. P. Trenberth and R. Summers. The current whereabouts of these specimens are unknown.

Genus *Cypraea* Linnaeus, 1758

Cypraea bregeriana var. ***barbara*** Kenyon, 1902
J. Conch. Lond. **10**(6): 183.
= *nomen inquirendum.*
Holotype: D4210, adult specimen, dead collected, from New Caledonia, collector and date of collection unknown. (Fig. 1A–C).

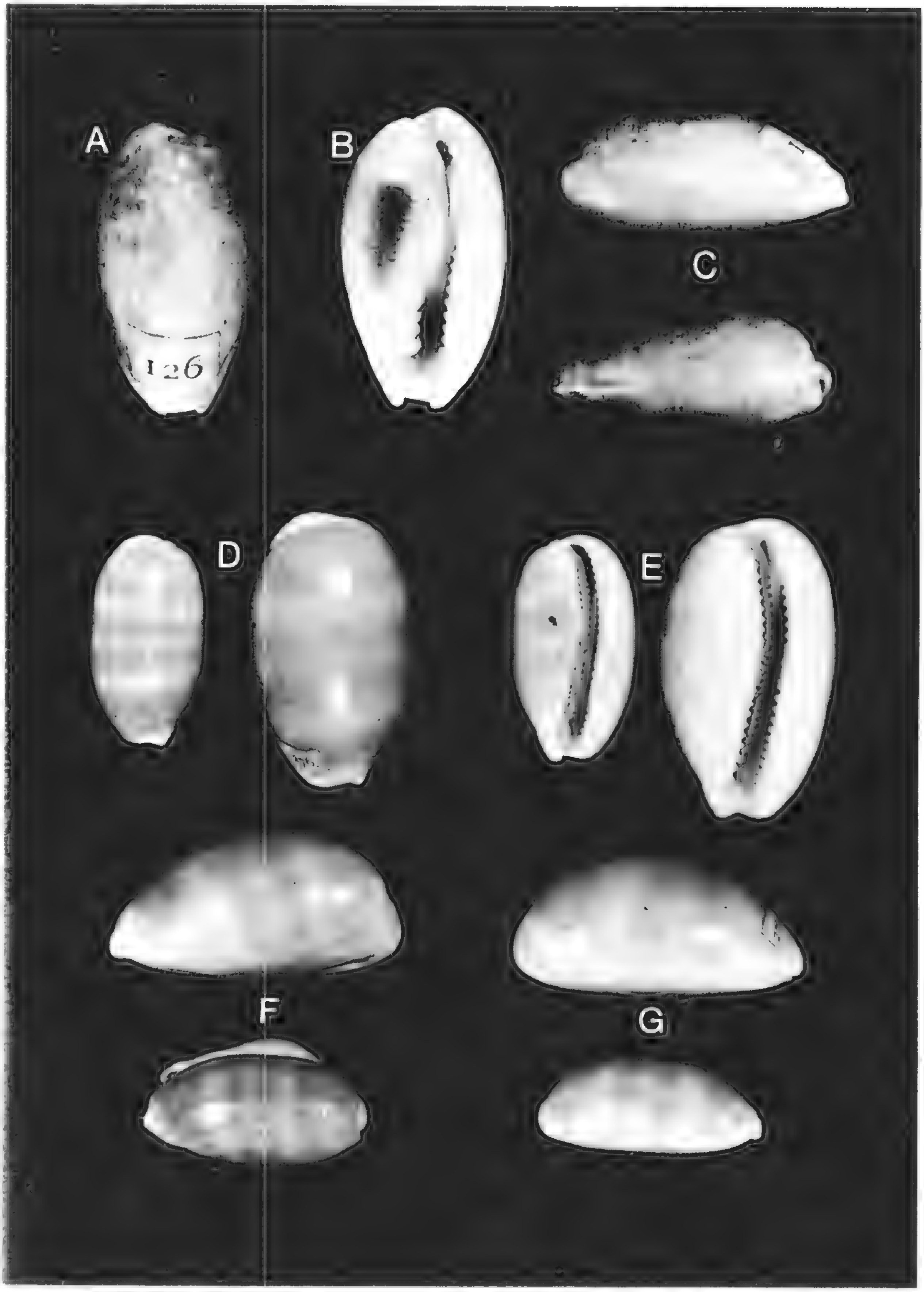

FIGURE 1. A–C: *Cypraea bregeriana* var. *barbara* Kenyon, 1902, holotype, SAM D4210, x 1.8. D–G: *Cypraea carneola* var. *rubiola* Kenyon, 1902, syntypes, SAM D3970, x 0.9.

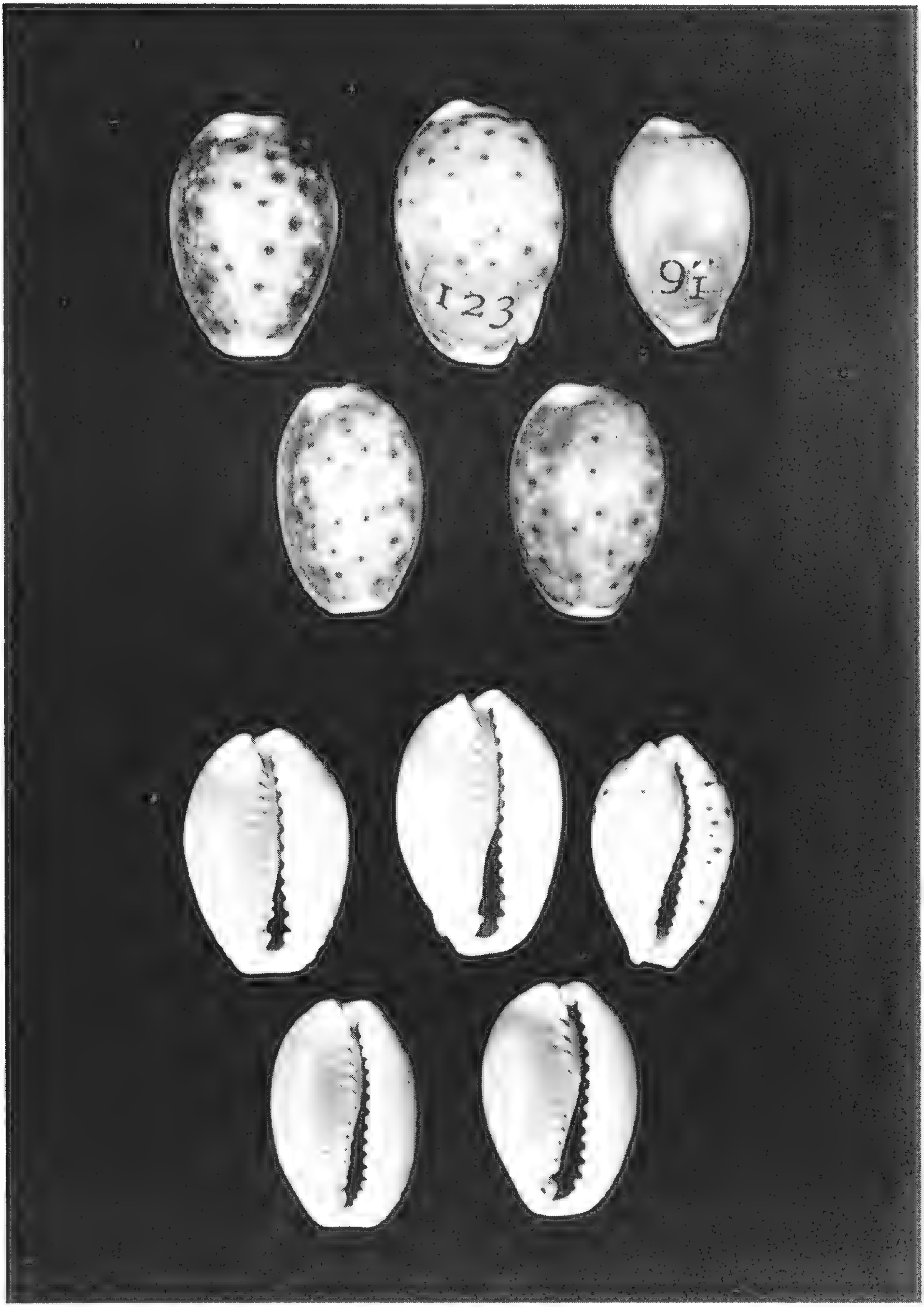

FIGURE 2. *Cypraea helvola* var. *borneensis* Kenyon, 1902, syntypes, SAM D3578, x 2.5.

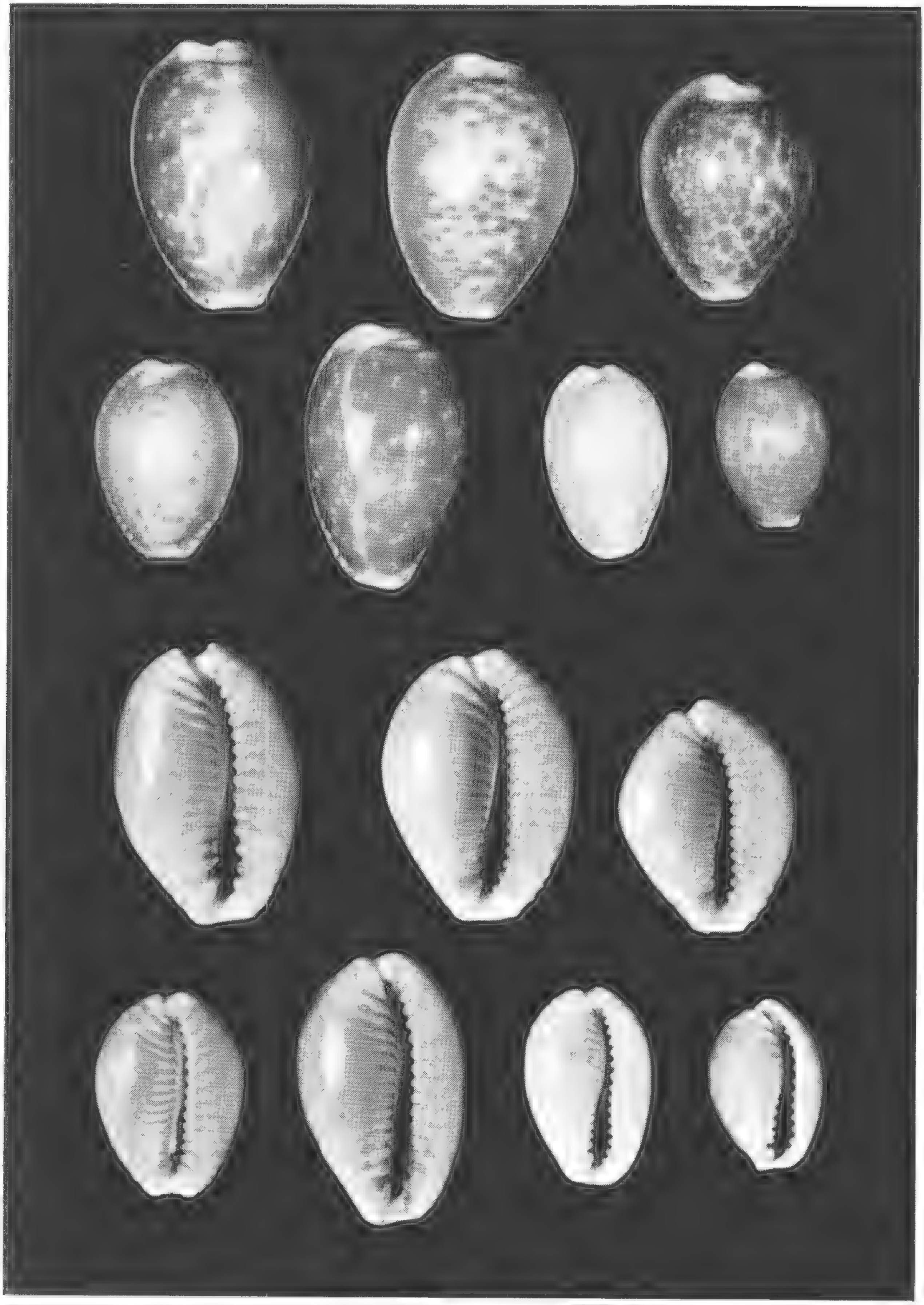

FIGURE 3. *Cypraea helvola* var. *timorensis* Kenyon, 1902, syntypes, SAM D3705, x 1.7.

Note: The oldest label with the specimen, in Sir Joseph Verco's handwriting, queries the name of this species, but as the specimen matches Kenyon's (1902) detailed description very closely, we believe it is the holotype. This name was not listed by Burgess (1985), and the holotype is clearly not a specimen of *Cypraea bregeriana* Crosse, 1868, as described by Burgess (1985). The specimen was not live collected, and cannot be identified with certainty as any currently recognised species. We believe, therefore, the most appropriate course is to regard this name as a *nomen inquirendum*.

Cypraea caputserpentis var. ***caputcolubri*** Kenyon, 1898
Proc. Malac. Soc. Lond. **3**(2): 79, fig. 3.
= *Cypraea caputserpentis* Linnaeus, 1758.
Syntype: D11561, one adult specimen, dead collected, no collection data.
Note: Kenyon (1898) mentions two specimens, one from the Hawaiian Islands and a 'fine live specimen from Lord Howe Island'. We assume that Kenyon's (1898) description and measurements refer to the live collected specimen, as this was the specimen that prompted her to describe the new variety. Unfortunately, this specimen cannot be located in our collections, and as we have most of the Kenyon Collection, we presume that it is lost. The SAM specimen listed here is smaller than the measurements given by Kenyon (1898), and as it is not live collected, we assume that it came from the Hawaiian Islands.

Cypraea carneola var. ***rubiola*** Kenyon, 1902
J. Conch. Lond. **10**(6): 184.
= *Cypraea carneola* Linnaeus, 1758
Syntypes: D3970, two specimens, one adult and one subadult, from the Hawaiian Islands, collector and date of collection unknown. (Fig. 1D–G).
Note: This name was not listed by Burgess (1985), but these specimens are conspecific with *C. carneola*.

Cypraea helvola var. ***borneensis*** Kenyon, 1902.
J. Conch. Lond. **10**(6): 183–4.
= *Cypraea helvola* Linnaeus, 1758.
Syntypes: D3578, five adult specimens, from Borneo, collector and date of collection unknown. (Fig. 2).
Note: This name was not listed by Burgess (1985), but the types are typical, but small, specimens of *C. helvola*.

Cypraea helvola var. ***timorensis*** Kenyon, 1902
J. Conch. Lond. **10**(6): 184.
= *Cypraea helvola* Linnaeus, 1758.
Syntypes: D3705, seven adult specimens, from Timor, collector and date of collection unknown. (Fig. 3).
Note: This name is not listed by Burgess (1985), but the types are typical specimens of *C. helvola*.

Cypraea irvineanae Cox, 1889
Proc. Linn. Soc. N.S.W. **4**: 659, pl. 19, figs 7–9.
= *Cypraea stolida* Linnaeus, 1758.
Holotype: D3772, adult specimen, from Cape Naturaliste, W.A., collector and date of collection unknown.
Note: This specimen lacks the dorsal brown blotch which is usually so typical of *C. stolida*.

Cypraea kaiseri Kenyon, 1897
Proc. Linn. Soc. N.S.W. **22**(1): 145.
= *Cypraea pyriformis* Gray, 1824.
Holotype: D3782, adult specimen, from Lagrange Bay, W.A., collector and date of collection unknown.

Cypraea kauilani Kenyon, 1900
Proc. Malac. Soc. Lond. **4**(2): 68, fig. 1.
= *Cypraea erosa* Linnaeus, 1758.
Holotype: D3781, adult specimen, from the Hawaiian Islands, collector and date of collection unknown. (Fig. 4A–C).
Note: This name was not listed by Burgess (1985), but we believe it is a specimen of the rare Hawaiian variety of *C. erosa*.

Cypraea mappa var. ***viridis*** Kenyon, 1902
J. Conch. Lond. **10**(6): 183.
= *Cypraea mappa* Linnaeus, 1758.
Syntypes: D3996, three adult specimens, from New Caledonia, collector and date of collection unknown.

Cypraea miliaris var. ***diversa*** Kenyon, 1902
J. Conch. Lond. **10**(6): 184.
= *Cypraea miliaris* Gmelin, 1791.
Syntypes: D3903, two adult specimens, from Shark Bay, W.A., collector and date of collection unknown.

Cypraea poraria var. ***vibex*** Kenyon, 1902
J. Conch. Lond. **10**(6): 184.
= *Cypraea poraria* Linnaeus, 1758.
Holotype: D18771, adult specimen, from New Caledonia, collector and date of collection unknown. (Fig. 4D–F).
Note: Kenyon (1902) mentions another specimen from the New Hebrides but it does not seem to have been used in her description, nor is it clear if it was before her at the time of description. We therefore assume that the SAM specimen is a holotype. This name was not listed by Burgess (1985), however, we believe it is simply an aberrant specimen of *C. poraria*.

Cypraea tigris amboolee Steadman & Cotton, 1943.
Rec. S. Aust. Mus. **7**(4): 332.
=*Cypraea tigris* Linnaeus, 1758.

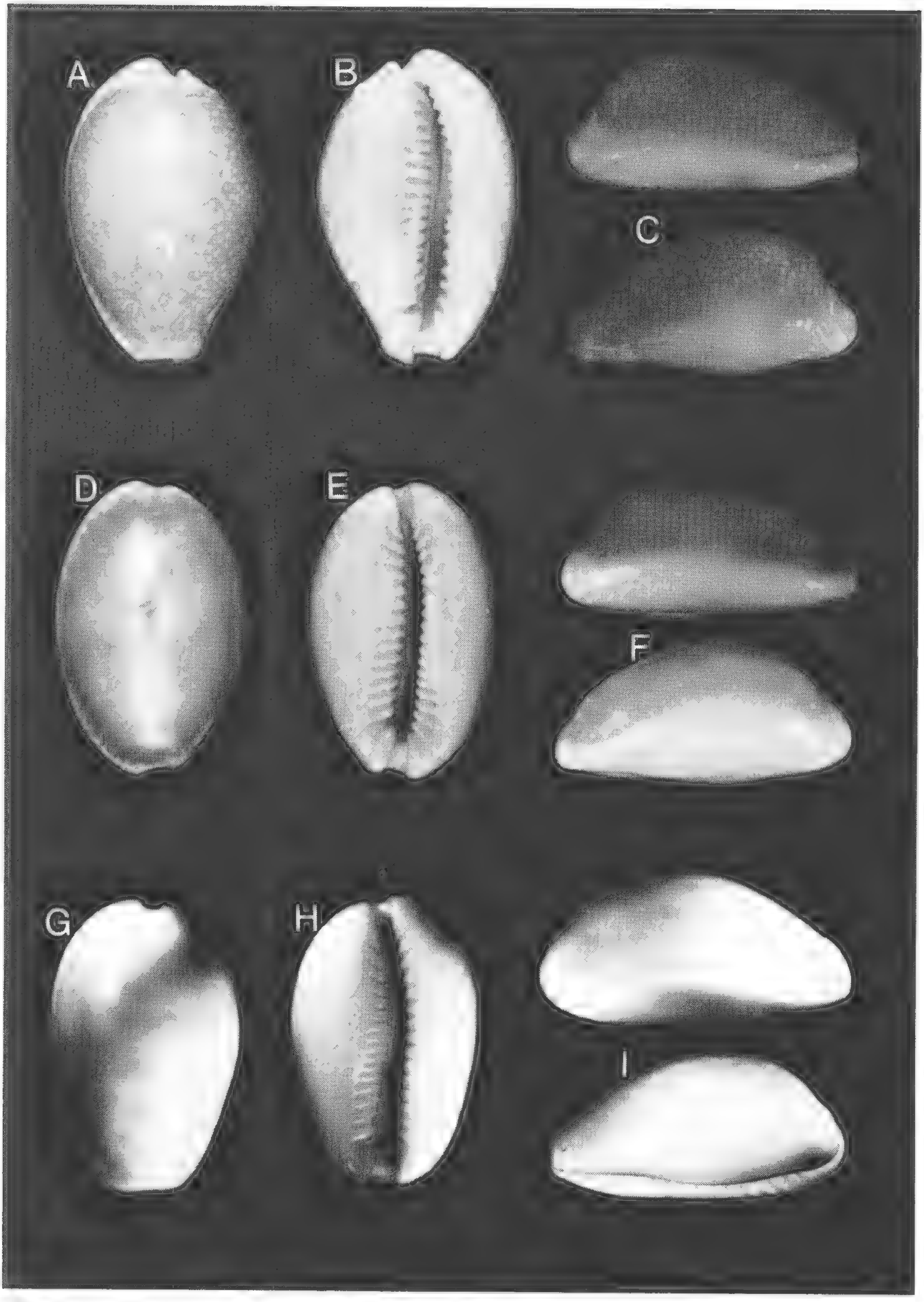

FIGURE 4. A–C: *Cypraea kauilani* Kenyon, 1900, holotype, SAM D3781, x 1.2. D–F: *Cypraea poraria* var. *vibex* Kenyon, 1902, holotype, SAM D18771, x 1.9. G–I: *Cypraea wilhelmina* Kenyon, 1897, holotype, SAM D14447, x 2.5.

Holotype: D14169, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention numerous specimens from Suva, Nadroga and Nairai, but did not designate any paratypes.

Cypraea tigris var. ***lineata*** Kenyon, 1902
J. Conch. Lond. **10**(6): 183.
= *Cypraea tigris* Linnaeus, 1758.
Syntype: D7107, one adult specimen, from Fiji, collector and date of collection unknown.
Note: Kenyon (1902) mentions several other specimens but these cannot be located in our collections with any confidence.

Cypraea tigris volai Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 332
= *Cypraea tigris* Linnaeus, 1758.
Holotype: D14168, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention numerous specimens from Suva and Nadroga, but did not designate any paratypes.

Cypraea (Notocypraea) trenberthae Trenberth, 1961
R. Soc. S. Aust. Malac. Sect. Occ. Publ. **15**: no pagination, fig.
= *Cypraea comptonii* Gray, 1847.
Holotype: D14616, live collected adult specimen, from Tumby Bay, Eyre Peninsula, S.A., collector and date of collection unknown.
Note: According to Trenberth (1961) there are four paratypes, two in his own collection, one in the collection of R. Summers, and one with the Malacological Society of Australia, Melbourne. The latter is in the Museum of Victoria (F31257), but the whereabouts of the other specimens is unknown.

Cypraea wilhelmina Kenyon, 1897
Proc. Linn. Soc. N.S.W. **22**(1): 145.
= *nomen inquirendum.*
Holotype: D14447, worn adult specimen, dead collected, from W.A., collector and date of collection unknown. (Fig. 4G–I).
Note: Kenyon (1897) also mentions one young specimen and three others from the same locality 'similar in shape and dentition to *C. poraria*' which she considers may be varieties of *C. wilhelmina*. We have been unable to locate these specimens in our collections. This name was not listed by Burgess (1985). This specimen may be an example of *C. poraria* Linnaeus, 1758, but differs on some points.

Genus *Erosaria* Troschel, 1863

Erosaria (Erosaria) helenae nasese Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 315.
= *Cypraea labrolineata* Gaskoin, 1849.
Holotype: D14142, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention another two specimens from Suva, but did not designate any paratypes.

Genus *Erronea* Troschel, 1863

Erronea errones bartletti Steadman & Cotton, 1946
Rec. S. Aust. Mus. **8**(3): 508.
= *Cypraea ovum* Gmelin, 1791.
Holotype: D15944, adult specimen, from Rossell Island, Papua New Guinea, collected by H. K. Bartlett, date of collection unknown.
Note: Steadman and Cotton (1946) mention two other specimens but did not designate paratypes. This name was not listed by Burgess (1985), but the holotype is obviously a specimen of *C. ovum*, not *C. errones* Linnaeus, 1758.

Erronea nimisserans kalavo Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 324.
= *Cypraea errones* Linnaeus, 1758.
Holotype: D14159, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention numerous specimens from Suva and Nadroga, but did not designate any paratypes.

Erronea nimisserans vivili Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 324.
= *Cypraea errones* Linnaeus, 1758.
Holotype: D14160, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.

Genus *Evenaria* Iredale, 1930

Evanaria(sic) asellus kawakawa Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 320.
= *Cypraea asellus* Linnaeus, 1758.

Holotype: D14151, adult specimen, dead collected, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention a further eleven specimens from Suva and Nadroga, but did not designate any paratypes.

Evanaria(sic) hirundo korolevu Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 320-1.
= *Cypraea hirundo* Linnaeus, 1758.
Holotype: D14152, adult specimen, from Korolevu, Viti Levu, Fiji, collected by W. R. Steadman, date of collection unknown. (Fig. 5A–C).
Note: Steadman and Cotton (1943) mention another thirty specimens from Suva and Nadroga, but did not designate any paratypes. Although Burgess (1985) synonymises this name with *C. hirundo*, the holotype appears to show more resemblance to *C. ursellus* Gmelin, 1791.

Evanaria(sic) ursellus vitiensis Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 321.
= *Cypraea kieneri* Hidalgo, 1906.
Holotype: D14153, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention another nineteen specimens from Suva and Nadroga, but did not designate any paratypes.

Genus *Guttacypraea* Iredale, 1935

Guttacypraea euclia Steadman & Cotton, 1946
Rec. S. Aust. Mus. 8(3): 506.
= *Cypraea pulicaria* Reeve, 1846.
Holotype: D11634, adult specimen with dried remains of animal, dredged live in 183m (100fm), Great Australian Bight, 90 miles west of Eucla, W.A., F.R.V. 'Endeavour', collected by J. C. Verco, Mar 1912.
Note: Steadman and Cotton (1946) mention other specimens but did not designate any paratypes.

Genus *Leporicypraea* Iredale, 1930

Leporicypraea mappa rewa Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 329.
= *Cypraea mappa* Linnaeus, 1758.
Holotype: D14164, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention another thirty nine specimens from Suva and Nadroga, but did not designate any paratypes.

Genus *Lyncina* Troschel, 1863

Lyncina lynx pacifica Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 330.
= *Cypraea lynx* Linnaeus, 1758.
Holotype: D14166, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention numerous specimens from Suva and Nadroga, but did not designate any paratypes.

Genus *Melicerona* Iredale, 1930

Melicerona melvilli vatu Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 322–3.
= *Cypraea felina* Gmelin, 1791.
Holotype: D14156, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention a further twenty nine specimens from Suva and Nadroga, but did not designate any paratypes. This name was not listed by Burgess (1985), but the holotype is a specimen of *C. felina*.

Genus *Monetaria* Troschel, 1863

Monetaria (Monetaria) moneta endua Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 317.
= *Cypraea moneta* Linnaeus, 1758.
Holotype: D14143, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention numerous specimens from Suva and Nadroga, but did not designate any paratypes.

Monetaria (Monetaria) moneta erua Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 317.
= *Cypraea moneta* Linnaeus, 1758.
Holotype: D14144, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention numerous specimens from Suva and Nadroga, but did not designate any paratypes.

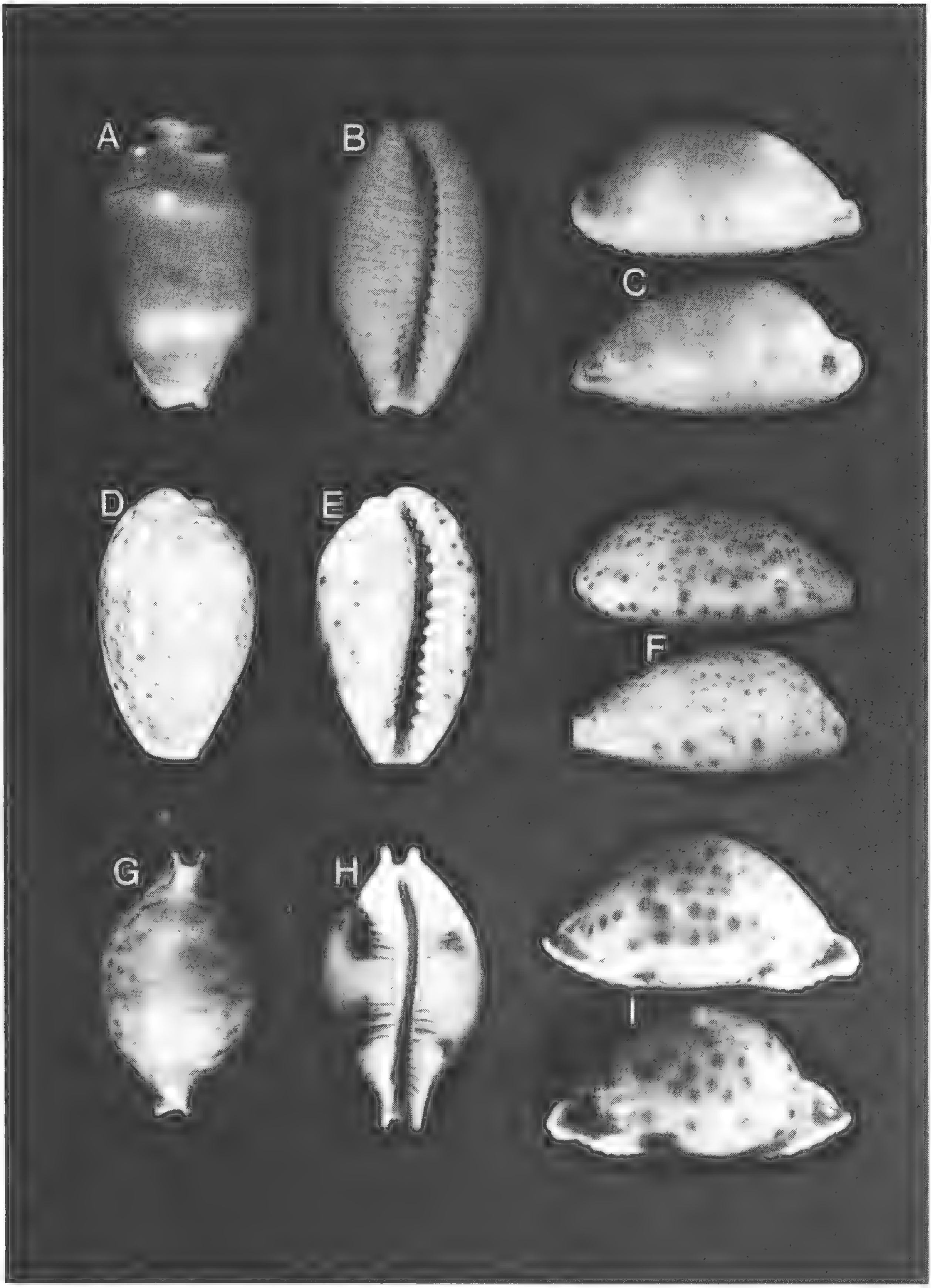

FIGURE 5. A–C: *Evanaria hirundo korolevu* Steadman & Cotton, 1943, holotype, SAM D14152, x 2.8. D–F: *Palmadusta lutea yaloka* Steadman & Cotton, 1943, holotype, SAM D14154, x 2.1. G–I: *Pustularia (Pustularia) cicerula jennisoni* Steadman & Cotton, 1943, holotype, SAM D14138, x 2.4.

Monetaria (Monetaria) moneta etolu Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 317.
= *Cypraea moneta* Linnaeus, 1758.
Holotype: D14145, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention numerous specimens from Suva and Nadroga, but did not designate any paratypes.

Genus *Notocypraea* Schilder, 1927

Notocypraea verconis Cotton & Godfrey, 1932
S. Aust. Nat. **13**:41, pl. 1, fig. 8.
= *Cypraea angustata* Gmelin, 1791.
Holotype: D13475, worn, damaged adult specimen, dead collected, from Gulf St Vincent, S.A., collector and date of collection unknown.
Note: Cotton and Godfrey (1932) list the registration number of the holotype as D10173. They also mention a number of other specimens but did not designate paratypes.

Genus *Palangerosa* Iredale, 1931

Palangerosa cylindrica wangga Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 323–4.
= *Cypraea cylindrica* Born, 1778.
Holotype: D14158, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention a further two specimens from Suva, but did not designate any paratypes.

Genus *Palmadusta* Iredale, 1930

Palmadusta lutea yaloka Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 322.
= *Cypraea yaloka* (Steadman & Cotton, 1943).
Holotype: D14154, adult specimen, from Nadroga, Fiji, collected by W. O. North, date of collection unknown. (Fig. 5D–F).
Note: Steadman and Cotton (1943) mention another specimen collected from the type locality by Steadman, but did not designate it as a paratype. Burgess (1985:141) regards this as a valid species, but confuses the issue by stating 'I examined Gray's type of *C. humphreysii* in the British Museum in 1968. It was identical with *C. yaloka* Steadman & Cotton', and further stating 'Since the original descriptions and illustrations of *C. humphreysii* and *C. nivea* clearly refer to *C. lutea* these names must be regarded as synonyms'. According to Burgess (1985) the specific conchological character separating *C. yaloka* from *C. lutea* Gmelin, 1791, is the number of white transverse bands on the dorsum, with *C. lutea* having two bands and *C. yaloka* three bands. Whether or not both species can be maintained cannot be resolved here, and would require the examination of a large series of specimens including the animal. However, if the three-banded form is a valid species and also matches the type of *C. humphreysii* Gray, 1825, then the correct name for this species is *C. humphreysii* not *C. yaloka* (Article 23, ICZN).

Genus *Paulonaria* Iredale, 1930

Paulonaria minoridens suvaensis Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 319–20.
= *Cypraea minoridens* Melvill, 1901.
Holotype: D14150, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention another seven specimens from the type locality, but did not designate any paratypes.

Genus *Ponda* Jousseaume, 1884

Ponda ventriculus topee Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 331.
= *Cypraea ventriculus* Lamarck, 1810a.
Holotype: D14167, adult specimen, from Kaduva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention another two specimens from the type locality, but did not designate any paratypes.

Genus *Pustularia* Swainson, 1840

Pustularia (Pustularia) cicercula jennisoni Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 310–1.
= *Cypraea bistrinotata* Schilder & Schilder, 1937.
Holotype: D14138, adult specimen, from Taveuni, Fiji, collected by R. C. Jennison, date of collection unknown. (Fig. 5G–I).
Note: Steadman and Cotton (1943) mention another eleven specimens from Suva, Taveuni and Naseli, but did not designate any paratypes. This name was not listed by Burgess (1985), but we believe it is probably a specimen of *C. bistrinotata*, not *C. cicercula* Linnaeus, 1758.

Pustularia (Annepona) margarita theeva Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 310.
= *Cypraea dillwyni* Schilder, 1922.
Holotype: D14137, adult specimen, from Nadroga, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention another five specimens from Nadroga, but did not designate any paratypes.

Pustularia (Pustularia) tricornis vulavula Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 311.
= *Cypraea cicercula* Linnaeus, 1758.
Holotype: D14139, adult specimen, from Nadroga, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention another nine specimens from Suva and Nadroga, but did not designate any paratypes.

Genus *Solvadusta* Iredale, 1935

Solvadusta subviridis kesata Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 322.
= *Cypraea subviridis* Reeve, 1835.
Holotype: D14155, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.

Genus *Staphylea* Jousseaume, 1884

Staphylea (Staphylea) nukulau Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 312.
= *Cypraea staphylaea* Linnaeus, 1758.
Holotype: D14140, adult specimen, from Nukulau, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention another twenty specimens from Suva and Nadroga, but did not designate any paratypes.

Staphylea (Purperosa)(sic) purperosa ruvaya Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 312–3.
= *Cypraea limacina* Lamarck, 1810b.
Holotype: D14141, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown.
Note: Steadman and Cotton (1943) mention another three specimens from Suva and Nadroga, but did not designate any paratypes.

Genus *Talostolida* Iredale, 1930

Talostolida subteres vava Steadman & Cotton, 1943
Rec. S. Aust. Mus. 7(4): 319.
= *Cypraea teres* Gmelin, 1791.
Holotype: D14149, adult specimen, from Suva, Fiji, collected by W. R. Steadman, date of collection unknown. (Fig. 6A–C).
Note: Steadman and Cotton (1943) mention another nine specimens from Suva and Nadroga, but did not designate any paratypes. This name was not listed by Burgess (1985), but we believe it is a specimen of *C. teres* rather than *C. subteres* Weinkauff, 1881.

Genus *Zoila* Jousseaume, 1884

Zoila episema Iredale, 1939
Aust. Zool. **9**(3): 300–1, pl. 27, figs 3, 4.
= *Cypraea venusta* Sowerby, 1846.
Holotype: D3980, adult specimen, from Cape Naturaliste, W.A., collector and date of collection unknown. (Fig. 6D–F).
Note: This specimen was originally purchased by Mrs A. Kenyon for £20 from Mrs Irving as the 'type' of *Cypraea thatcheri* Cox, 1869, and later acquired by Sir Joseph Verco and donated to SAM. Verco, however, recognised it was not the type of Cox's species, which was sent by Cox to the Natural History Museum, London. Type unique.

Zoila friendii vercoi Schilder, 1930
Zool. Anz. **92**(1/2): 74–5.
= *Cypraea friendii* Gray, 1831.
Holotype: D14124(ex D969), adult specimen, from Esperance, W.A., collected by J. C. Verco, date of collection unknown. (Fig. 6G–I).

Zoila rosselli Cotton, 1948
Trans. R. Soc. S. Aust. **72**(1): 30–31, pl. 1, figs 1–6.
= *Cypraea rosselli* (Cotton, 1948).
Holotype: D14220, adult specimen, dorsum eroded with acid, from a beach near North Wharf, Fremantle, W.A., collected by H. Rossell, date of collection unknown.
Note: Cotton (1948) mentions another five specimens, but did not designate any paratypes.

Family OVULIDAE

Genus *Crenavolva* Cate, 1973

Crenavolva cruenta Gowlett-Holmes & Holmes, 1989
Trans. R. Soc. S. Aust. **113**(4): 208–13, figs 2, 3(fig. only), 7(caption only).

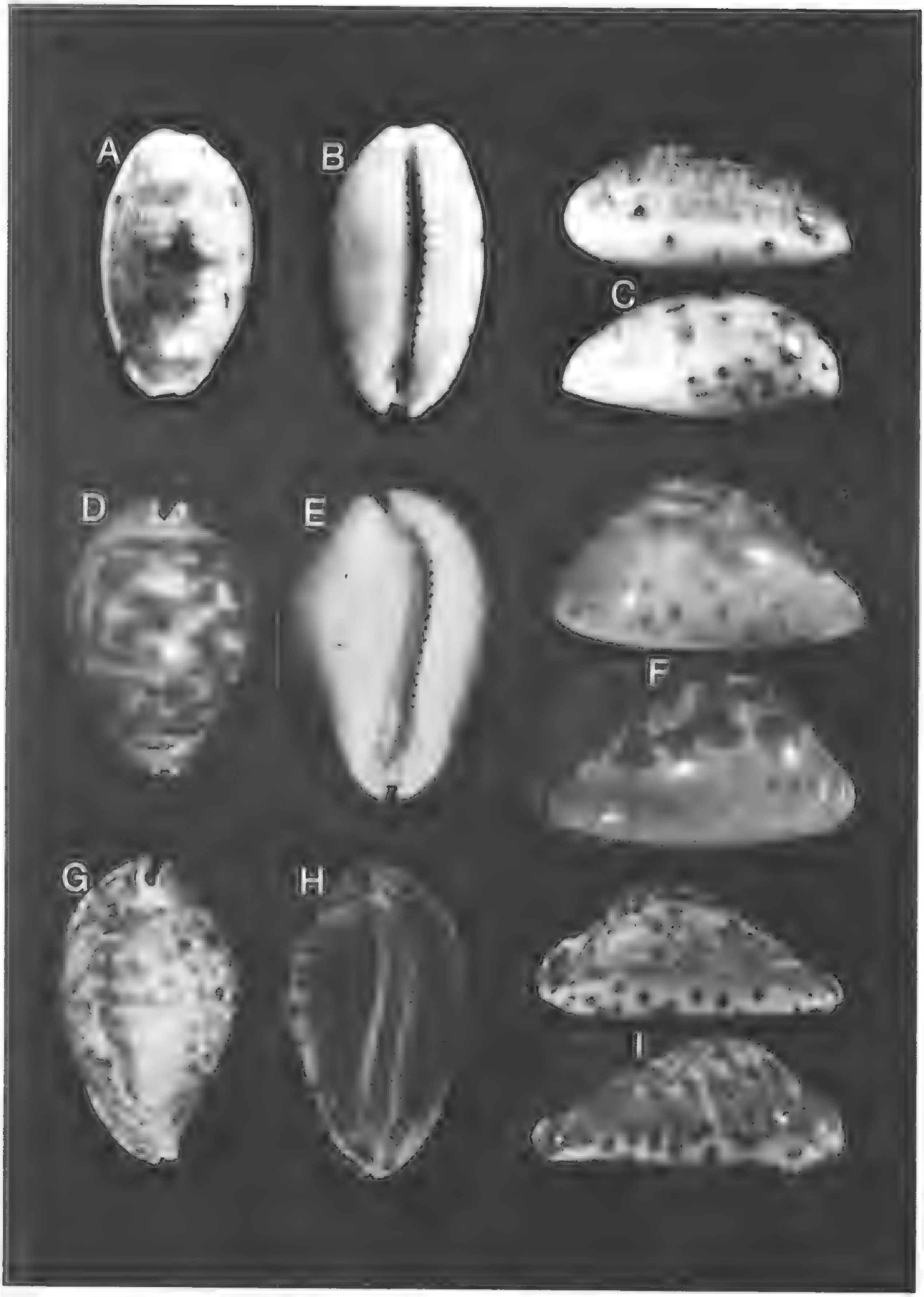

FIGURE 6. A–C: *Talostolida subteres vava* Steadman & Cotton, 1943, holotype, SAM D14149, x 1.7. D–F: *Zoila episema* Iredale, 1939, holotype, SAM D3980, x 0.6. G–I: *Zoila friendii vercoi* Schilder, 1930, holotype, SAM D14124, x 0.5.

Holotype: D18431, adult specimen with dried animal, from on gorgonian coral (*Echinogorgia* sp.), in 15 m, from 1.6 km east of Point Douglas, northern Spencer Gulf, S.A., collected by N. J. C. Holmes, 5 May 1988.
Paratypes: D18432, 31 specimens (6 immature), all with dried animals, with same collection data as holotype. D18433, 38 specimens (14 immature) with animals, in spirit, with same collection data as holotype. D18437, 11 adult specimens, all with dried animals, with same collection data as holotype.
Note: Two paratypes from D18432 are now in the collections of the Academy of Natural Sciences, Philadelphia. In the original description of this species (Gowlett-Holmes & Holmes, 1989), figs 3 and 7 were transposed, although the captions are correct.

Genus *Primovula* Thiele, 1925

Primovula (Primovula) heleneae Cate, 1973
Veliger Suppl. **15**: 43, fig. 89.
Holotype: D15943, 1 worn, damaged, adult specimen, dredged dead in Gulf St Vincent or Spencer Gulf, S.A., collected by J. C. Verco, date of collection unknown.
Note: This specimen is also a paratype of *Prosimnia verconis* Cotton & Godfrey, 1932, also listed here, but Cate (1973) recognised it as a different species.

Genus *Prosimnia* Schilder, 1927

Prosimnia verconis Cotton & Godfrey, 1932
S. Aust. Nat. **13**: 46, pl. 1, fig. 15.
= *Crenavolva verconis* (Cotton & Godfrey, 1932).
Holotype: D13476, worn, adult specimen, dredged dead in 65 m (35 fm), off St Francis Island, Nuyts Archipelago, S.A., collected by J. C. Verco, date of collection unknown.
Paratype: D15943, one worn, damaged, adult specimen, dredged dead in Gulf St Vincent or Spencer Gulf, S.A., collected by J. C. Verco, date of collection unknown.
Note: There were originally 3 specimens (see Gowlett-Holmes & Holmes, 1989). The above paratype (D15943) does not represent this species and was selected by Cate (1973) as the holotype of *Primovula (Primovula) heleneae* Cate, 1973, also listed here.

Family TRIVIIDAE

Subfamily TRIVIINAE

Genus *Cleotrivia* Iredale, 1930

Cleotrivia bathypilula Iredale, 1935
Aust. Zool. **8**(2): 100.
= *Niveria (Cleotrivia) pilula bathypilula* (Iredale, 1935).
Syntypes: D876, three specimens, dredged in 22–25 m (12–14 fm), King George Sound, W.A., collected by J. C. Verco, date of collection unknown. D909, one adult specimen, dredged in 148 m (81 fm), Great Australian Bight, 80 miles west of Eucla, W.A., F.R.V. 'Endeavour', collected by J. C. Verco, Mar 1912. D910, one specimen, dredged in 132 m (72 fm), Great Australian Bight, 40 miles west of Eucla, W.A., F.R.V. 'Endeavour', collected by J. C. Verco, Mar. 1912.
Note: D909 and D910 are the holotype and paratype respectively of *Niveria (Cleotrivia) pilula euclaensis* Cate, 1979, also listed here, an unnecessary replacement name.

Genus *Niveria* Jousseaume, 1884

Niveria (Cleotrivia) corallina Cate, 1979
San Diego Soc. Nat. Hist. Mem. **10**: 56, fig. 70.
Holotype: D16221, adult specimen, ex Kenyon Collection, locality and date of collection unknown.
Note: Cate (1979) states that the type locality of this species is 'unknown: thought to be from South Australia'. As this specimen is from the Kenyon Collection, it is most unlikely to be from South Australia, and the type locality should be regarded as unknown. The registration number cited by Cate (1979) for this species (D4095C) is an old number for D16221.

Niveria (Cleotrivia) dorsennus Cate, 1979
San Diego Soc. Nat. Hist. Mem. **10**: 56, fig. 69.
Holotype: D16222, adult specimen, ex Kenyon Collection, locality and date of collection unknown.
Note: Cate (1979) states that the type locality of this species is 'unknown: thought to be from South Australia'. As this specimen is from the Kenyon Collection, it is most unlikely to be from South Australia, and the type locality should be regarded as unknown. The registration number cited by Cate (1979) for this species (D4095B) is an old number for D16222.

Niveria (Cleotrivia) meridionalis Cate, 1979
San Diego Soc. Nat. Hist. Mem. **10**: 54, fig. 68.
Holotype: D16223, adult specimen, ex Kenyon Collection, locality and date of collection unknown.
Note: Cate (1979) states that the type locality of this species is 'not known: thought to be from the south Australian coast'. As this specimen is from the Kenyon Collection, it is most unlikely to be from South Australia, and the type locality should be regarded as unknown. The registration number cited by Cate (1979) for this species (D4095A) is an old number for D16223.

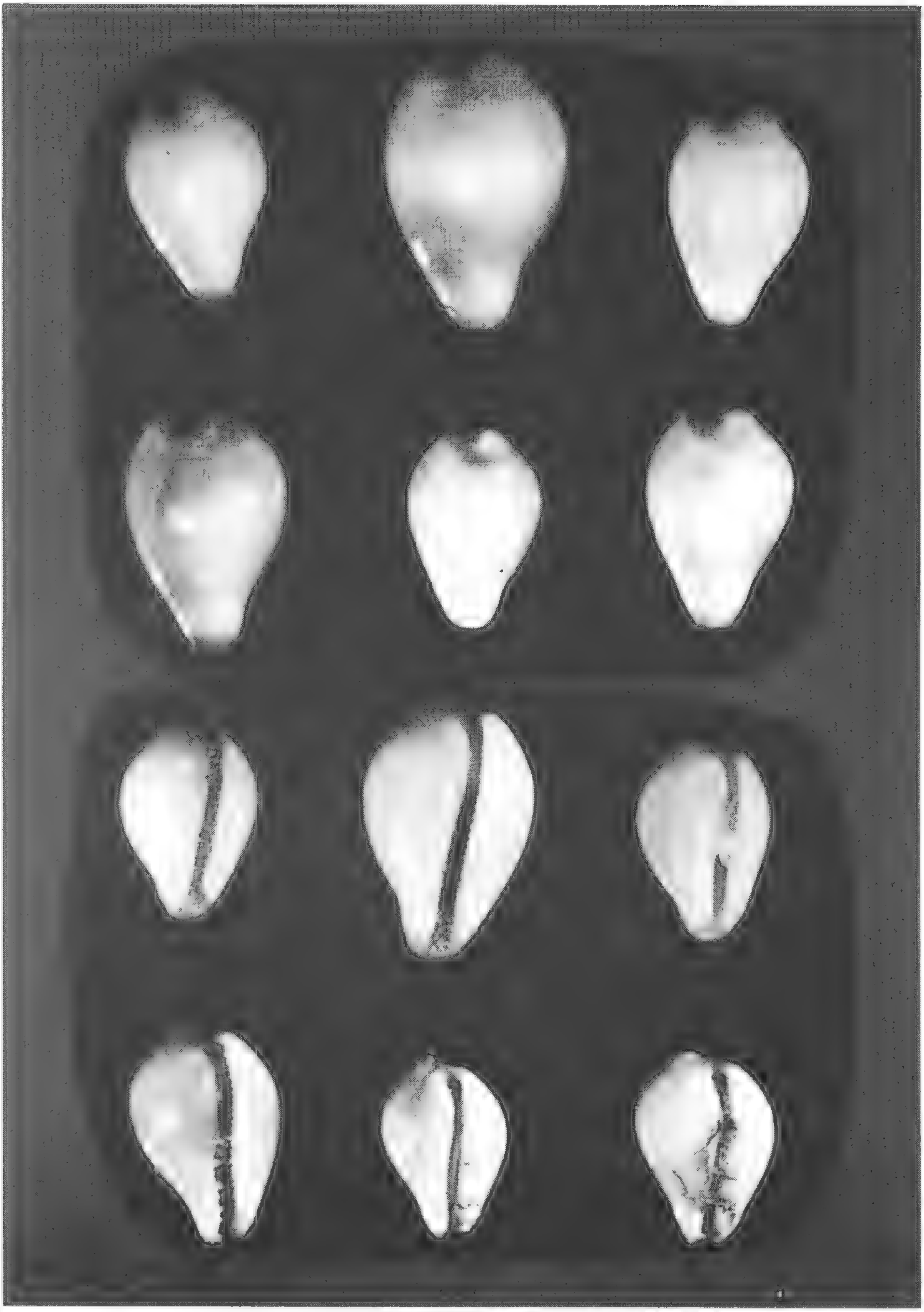

FIGURE 7. *Erato bimaculata* Tate, 1878, syntypes, SAM D913, x 8.

Niveria (Cleotrivia) pilula euclaensis Cate, 1979
San Diego Soc. Nat. Hist. Mem. **10**: 59, fig. 73.
= *Niveria (Cleotrivia) pilula bathypilula* (Iredale, 1935).
Holotype: D909, adult specimen, dredged in 148 m (81 fm), Great Australian Bight, 80 miles west of Eucla, W.A., F.R.V. 'Endeavour', collected by J. C. Verco, Mar 1912.
Paratype: D910, one specimen, dredged in 132 m (72 fm), Great Australian Bight, 40 miles west of Eucla, W.A., F.R.V. 'Endeavour', collected by J. C. Verco, Mar 1912.
Note: Cate (1979) erected this replacement name for *Cleotrivia bathypilula* Iredale, 1935, believing the latter to be invalid. However, Iredale's (1935) name was validly erected.

Genus *Trivia* Broderip, 1837

Trivia acutisulcata Kenyon, 1900
Proc. Malac. Soc. Lond. 4(2): 69, fig. 2.
= *Niveria (Cleotrivia) globosa* (Sowerby, 1832).
Holotype: D4085, adult specimen, ex Kenyon Collection, locality and date of collection unknown.

Genus *Trivirostra* Jousseaume, 1884

Trivirostra cydarum Cate, 1979
San Diego Soc. Nat. Hist. Mem. **10**: 95, fig. 151.
Holotype: D16224, adult specimen, ex Kenyon Collection, locality and date of collection unknown.
Note: Cate (1979) states that the type locality of this species is 'unknown....thought to have been from the Gulf St Vincent area of South Australia (34°55'S, 138°10'E)'. As this specimen is from the Kenyon Collection, it is most unlikely to be from South Australia, and the type locality should be regarded as unknown. The registration number cited by Cate (1979) for this species (D4095) is an old number for D16224.

Subfamily ERATOINAE

Genus *Erato* Risso, 1826

Erato bimaculata Tate, 1878
Trans. Proc. Rep. Phil. Soc. Adel. **1**: 88.
Syntypes: D913, six specimens, dead collected, in beach sand, from Aldinga and Marino, near Adelaide, S.A., collected by R. Tate, date of collection unknown. (Fig. 7).
Note: One of the above specimens is labelled 'type example', but this was probably added later by B. C. Cotton. Tate (1878) also mentions another four specimens, but the current whereabouts of these is unknown.

Acknowledgments

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JEFFOCORIS GEN. N. – A NEW PODOPINE GENUS FROM AUSTRALIA (HETEROPTERA: PENTATOMIDAE)

J. DAVIDOVÁ-VILÍMOVÁ

Summary

The new genus Jeffocoris and new species J. grossi of the subfamily Podopinae are described from Australia, where nine podopine genera are now known. Jeffocoris is compared with the related genus Deroploopsis.

JEFFOCORIS GEN. N. – A NEW PODOPINE GENUS FROM AUSTRALIA (HETEROPTERA: PENTATOMIDAE)

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DAVIDOVÁ-VILÍMOVÁ, J. 1993. *Jeffocoris* gen. n. – a new podopine genus from Australia (Heteroptera: Pentatomidae). *Rec. S. Aust. Mus.* **26**(2):105–109.

The new genus *Jeffocoris* and new species *J. grossi* of the subfamily Podopinae are described from Australia, where nine podopine genera are now known. *Jeffocoris* is compared with the related genus *Deroploopsis*.

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Schouteden (1906), in the first revision of genera of the subfamily Podopinae (as Graphosomatinae), listed five genera from the tribe Graphosomatini (as Graphosomataria) as occurring in Australia: *Deroploa* Westwood, 1835; *Testrica* Walker, 1867, with the new subgenus *Protestrica; Testricoides Schouteden*, 1905 (a junior synonym of *Dandinus* Distant, 1904); *Numilia* Stål, 1867 and *Deroploopsis*. The last genus was originally described by Schouteden (op. cit.), with the type species *Deroploa curvicornis* Stål, 1876. Stål (1876), in one of the first papers on Australian Pentatomoidea, mentioned only three podopine genera: *Testrica, Numilia* and *Deroploa.*

Musgrave (1930) published the next revision of Australian representatives of the subfamily Podopinae (as Graphosomatinae). He listed eight genera from the tribe Graphosomatini: *Deroploopsis* Schouteden, 1906; *Deroploa*; *Eufroggattia* Goding, 1903; *Numilia; Dandinus; Testrica; Protestrica;* and *Propetestrica;* the last was described (op. cit.) as a new genus.

Gross (1975), in the last comprehensive study of Australian Pentatomoidea, classified the representatives of the Podopinae in two genus groups: genus group *Podops* Laporte, 1832 (approximately the tribe Podopini) and genus group *Tarisa* Amyot and Serville, 1843 (approximately the tribe Graphosomatini). Gross mentioned five podopine genera from the genus group *Tarisa* occurring in South Australia: *Deroploopsis, Dandinus, Testrica, Protestrica* and *Propetestrica.*

A new podopine genus from Western Australia was recognised during a complex revision of all genera of the subfamily Podopinae. Nine podopine genera are now known from Australia: *Dandinus, Deroploa, Deroploopsis, Eufroggattia, Numilia, Propetestrica, Protestrica, Testrica,* and the new genus, *Jeffocoris.*

Methods

The terminology of male external genitalia follows Davidová-Vilímová & McPherson (1992).

The pygophore in this paper is illustrated upside down with the dorsal rim down, ventral rim up. This allows comparison of these illustrations with some recent ones of pentatomoid (Schaefer, 1977; Davidová-Vilímová & McPherson, 1992) or podopine (Schaefer, 1981) pygophores.

Strongly sclerotised and pigmented parts are represented by stippling on the illustrations.

Jeffocoris gen. n.

Type species: *Jeffocoris grossi* sp. n. (by monotypy).

Etymology

The name of the genus is derived from the personal name of Jeff Parris. The gender is masculine.

Diagnosis

Ground colour dark brown with pale brown to beige spots on head and pronotum, and longitudinal keels on pronotum and scutellum.

Head slightly slanted ventrally; with almost rectangular outline, apex broadly rounded (Fig. 1). Approximately anterior 1/3 of length of head recurved dorsally at right angle.

Pronotum with long, robust process with wide, undivided apex at lateral angle. One medial longitudinal keel and two sublateral oblique keels (Fig. 2).

Orifice of metapleural scent gland on top of protuberance bent in several places; protuberance placed halfway along width of metapleura and at 1/4 of length from posterior margin of metapleura. Auricle at orifice absent, evaporative area represented by fine-grained surface of protuberance and of small plate around its base.

Scutellum conspicuously long, exceeding apex of abdomen, narrow; about 1/2 of corium and large part of clavus left uncovered by scutellum (Fig. 4). Proepisternum with flattened anterior margin (Fig. 3).

Abdominal sterna 3–7 with two short trichobothria laterally on each side, trichobothria in transverse position to each other, lateral trichobothrium at spiracular line, shorter than medial one.

Male external genitalia: Paramere conspicuously small, peduncle gradually widens to hypophysis, which narrows to its apex (Figs 8–11). Large, flat infolding of lateral rim of pygophore the most conspicuous structure on pygophore (Figs 5,6), at right angle to lateral wall. Phallus with long, cylindrical phallotheca; conjunctiva with unpaired membranous process divided into two long apices crossing one another (Figs 12–14). Endophallic duct forms short, wide, sclerotised vesica; secondary gonopore slightly recurved ventrally (Figs 12–14).

Diagnosis

Jeffocoris is similar and probably closely related to *Deroploopsis*. The latter genus has five species, three of which were studied during revision of the Podopinae: *D. curvicornis* (Stål, 1876), *D. recticornis* Musgrave, 1930 and *D. trispinosus* Musgrave, 1930.

These two genera share several apomorphic characters within the Podopinae: lateral angle of pronotum with long, robust process; anterior margin of proepisternum flattened; medial longitudinal keel on pronotum developed along the entire length of pronotum; scutellum conspicuously long, exceeding apex of abdomen; evaporative area small, only on metapleura, auricle absent.

Jeffocoris differs from *Deroploopsis* by the following characters.

Head: Sexual dimorphism in shape of head exists in *Deroploopsis*: Head of male is elongate, long mandibular plates do not touch one another before anteclypeus, their apical parts are recurved dorsally at obtuse angle, not at right angle; head of female is of approximately rectangular outline. Only males of *Jeffocoris* are known. Outline of head of male is almost rectangular, mandibular plates touch one another before anteclypeus, about apical 1/3 of length of head is recurved dorsally at right angle (Fig. 1).

Pronotum: Larger, triangular process is developed at anterior angle of pronotum in *Deroploopsis*. Conspicuously long, apically divided process present at lateral angle of pronotum in *Deroploopsis*. Only small process is developed at anterior angle, and process at lateral angle is not divided in *Jeffocoris* (Fig. 2). Pronotum of *Deroploopsis* bears medial longitudinal keel, and laterally one anterior tubercle. Pronotum of *Jeffocoris* bears medial longitudinal keel, and short, sublateral oblique keels on anterior part (Fig. 2).

Orifice of scent gland is at centre of protuberance in *Deroploopsis*, posteromedial in *Jeffocoris*.

Entire scutellum of *Deroploopsis* is brown and only slightly exceeds apex of abdomen. Scutellum of *Jeffocoris* is brown and bears a medial longitudinal beige keel; it conspicuously exceeds apex of abdomen.

Shape of paramere of *Deroploopsis* is very similar to that of *Jeffocoris* (see description) but bears a small membrane connected to peduncle. Paramere of *Jeffocoris* lacks a membrane.

Wide infolding of ventral rim of pygophore is developed in *Deroploopsis*; only narrow infolding is developed in *Jeffocoris*.

Vesica is short, entirely recurved distally in *Deroploopsis*; only slightly recurved posteroventrally in *Jeffocoris*. Medial penial lobe is of more complicated shape in *Deroploopsis* than in *Jeffocoris*.

Jeffocoris grossi sp. n.

Etymology

The name of the species is derived from that of the hemipterist G. F. Gross.

Material examined

Only the type material is known. Holotype: male, West Australia, Dedari, 40 mi W of Coolgardie, 11–21 January 1963, R. E. Turner. Paratype: male, from the same locality. Both type specimens are deposited in the collection of the Natural History Museum, London.

Distribution

Western Australia.

Description

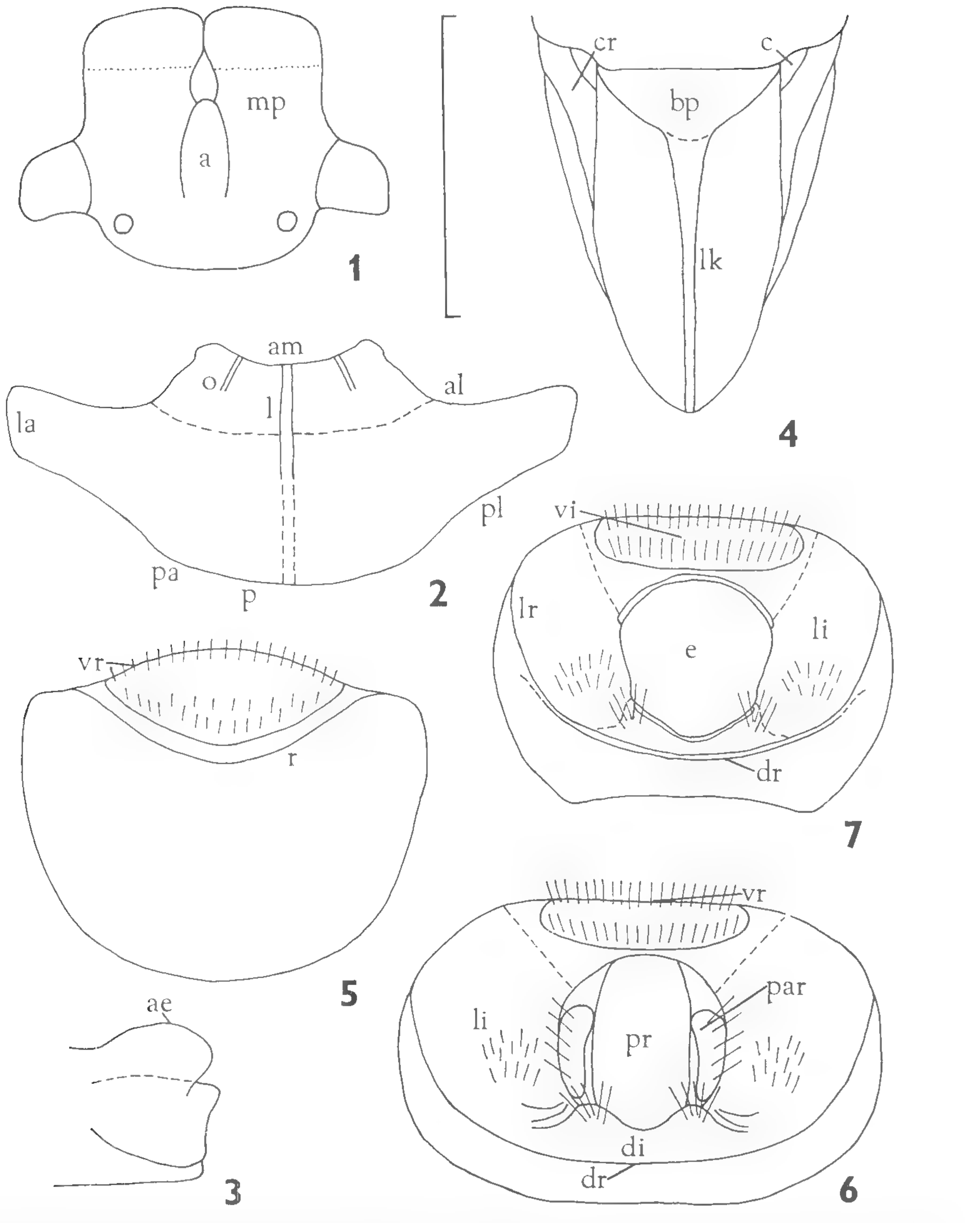
Measurements (in mm, N = 2): Total body length: 4.5 – 4.7; head length: 0.7 – 0.8, width: 1.1 – 1.2; pronotum length: 1.3 – 1.5, width: 4.1 – 4.7.

Head (Fig. 1): Eyes large, a little protuberant (Fig. 1). Mandibular plates about 1/3 longer than anteclypeus, touching one another before anteclypeus. Anterior 1/3 of length of head recurved dorsally at right angle. Anteclypeus narrow, short (Fig. 1). Dorsal surface of head almost flat. Antennae five-segmented, segment 5 longest, segment 1 shortest.

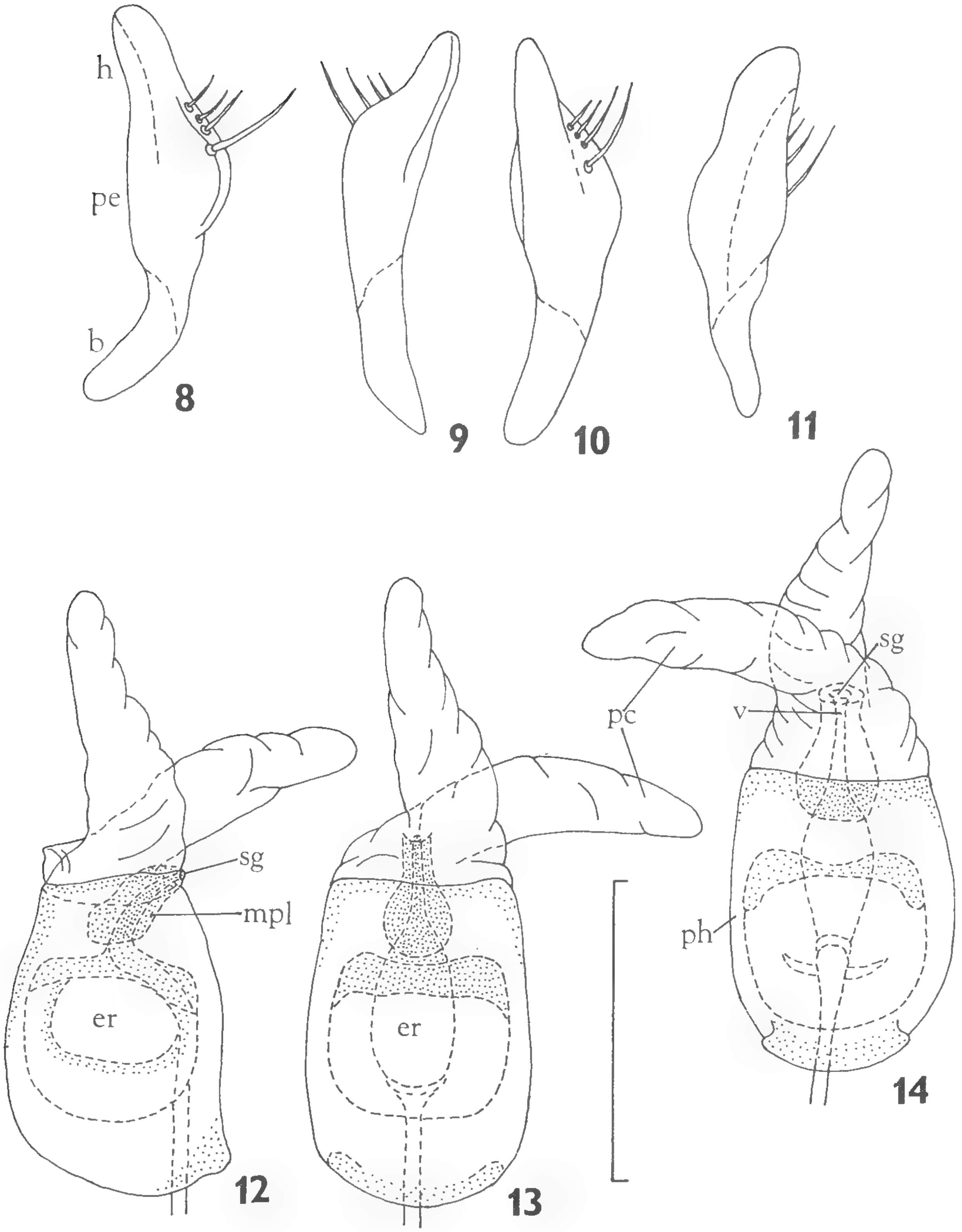
Bucculae short, conspicuously high, with straight ventral margin; dark brown, with yellow stripe on ventral margin. Apex of labium reaching to mesocoxae, segment 1 shorter than bucculae.

Pronotum (Fig. 2): Anterior margin concave; anterior angle with small triangular tooth-shaped process, slanted to beginning of conspicuously concave anterolateral margin. Lateral angle with long, robust process. Posterolateral and posterior margins almost straight, posterior angle rounded.

Median longitudinal, conspicuously elevated keel on anterior 1/3 of pronotum, only slightly elevated on posterior 2/3 of pronotum. Short, oblique keel sublaterally on each side at anterior margin. Transverse keel vaguely outlined on anterior part of pronotum.



FIGURES 1–7. *Jeffocoris grossi*. **1**, head, dorsal view, dotted line = apical part of head recurved dorsally; **2**, pronotum, dorsal view, transverse dashed line = transverse keel, longitudinal dashed line = posterior part of longitudinal keel; **3**, left proepisternum, ventral view; **4**, scutellum, dorsal view, dashed line = posterior outline of basal plate; **5**, pygophore, posterior view; **6**, pygophore, dorsal view, dashed line = contact of infoldings of lateral rim and of ventral rim; **7**, dissected pygophore, dorsal view. **a**, anteclypeus; **ae**, anterior margin of proepisternum; **al**, anterolateral margin of pronotum; **am**, anterior margin of pronotum; **bp**, basal plate of scutellum; **c**, clavus; **cr**, corium; **di**, infolding of dorsal rim of pygophore; **dr**, dorsal rim of pygophore; **e**, external opening of pygophore; **l**, longitudinal keel on pronotum; **la**, lateral angle of pronotum; **li**, infolding of lateral rim of pygophore; **lk**, longitudinal keel on scutellum; **lr**, lateral rim of pygophore; **mp**, mandibular plate; **o**, oblique keel on pronotum; **p**, posterior margin of pronotum; **pa**, posterior angle of pronotum; **par**, paramere; **pl**, posterolateral margin of pronotum; **pr**, proctiger; **r**, ridge on ventral wall of pygophore; **vi**, infolding of ventral rim of pygophore; **vr**, ventral rim of pygophore. Scale line: 0.9 mm: fig. 1; 1 mm: figs. 5–7; 1.1 mm: fig. 3; 1.8 mm: fig. 2; 2.4 mm: fig. 4.



FIGURES 8–14. *Jeffocoris grossi*. **8–11,** left paramere, **8,** lateral view, **9,** medial view, **10,** posterior view, **11,** anterior view; **12–14,** phallus, **12,** lateral view, **13,** dorsal view, **14,** ventral view. **b,** base of paramere; **er,** ejaculatory reservoir; **h,** hypophysis of paramere; **mpl,** medial penial lobe; **pc,** process of conjunctiva; **pe,** peduncle of paramere; **ph,** phallotheca; **sg,** secondary gonopore; **v,** vesica. Scale line: 0.3 mm: figs. 12–14; 0.6 mm: figs. 8–11.

Venter of thorax: Sternal sulcus conspicuously concave, with fine, short pubescence. Anterior margin of proepisternum elongated and flattened (Fig. 3); margins of meso- and metaepisternum rounded. Protuberance with orifice of scent gland narrow at base, widened to apex.

Scutellum and uncovered parts of dorsum of abdomen (Fig. 4): Width of base of scutellum the same as distance between posterior angles of pronotum.

Scutellum slightly convex; triangular basal plate developed at its base; longitudinal, elevated keel beginning from basal plate reaching to apex. Frena developed as oblique, low sclerite on ventral surface of scutellum, reaching to 1/3 of length.

Venter of abdomen: Venter conspicuously flattened medially, base without distinct structures. Spiraculae large, distinctly elevated.

Male external genitalia: Pygophore (Figs 5–7) oval in dorsal view; external opening dorsal. Ventral wall slightly convex in posterodorsal view; dorsal 1/4 flattened, with sparse pubescence, delimited by low, wide ridge (Fig. 5).

Ventral rim slightly convex in dorsal view (Fig. 6). Infolding of rim wide (Figs 6, 7), almost at right angle to ventral wall, concave medially.

Dorsal rim convex in dorsal view (Fig. 6). Infolding of rim wide, at obtuse angle to dorsal wall, sublateral tufts of pubescence near external opening of pygophore (Figs 6, 7). Infolding convex medially, gradually concave laterally, where infolding merges with infolding of lateral rim.

Lateral rim convex in dorsal view (Fig. 6). Infolding of rim conspicuously wide, at right angle to lateral wall, with sparse pubescence (Figs 6, 7). Infolding concave medially, gradually convex ventrally, where infolding merges with infolding of ventral rim.

External opening in dorsal view without excavations for parameres (Fig. 7). Proctiger of simple shape (Fig. 6).

Paramere (Figs 8–11) with four rigid setae on beginning of hypophysis; apex of paramere directed ventrally in natural position in pygophore.

Phallus (Figs 12–14) with phallotheca strongly sclerotised on following parts: ventral side basally, dorsal side apically, and entire apex. Ejaculatory reservoir of complicated shape (not studied in detail) in middle of phallotheca.

Conjunctiva represented by membranous process (Figs 13, 14).

Vesica begins from middle of apex of ejaculatory reservoir, ending in secondary gonopore directed posteroventrally (Fig. 12). Strongly sclerotised, unpaired medial penial lobe surrounds vesica, only secondary gonopore left free. Medial penial lobe cylindrical (Fig. 12), closed on both sides except base of dorsum.

Phallus directed in natural position in pygophore anteriorly (phallotheca) and dorsally (conjunctiva and vesica).

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HUNTING WITH HIDES : ETHNO-HISTORICAL REFLECTIONS ON VICTORIA RIVER STONE STRUCTURES

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Summary

The remains of distinctive man-made stone structures exist throughout much of the Victoria River District of the Northern Territory. These features were constructed as hunting hides, utilised in trapping birds of prey. Aboriginal accounts reveal the hunting methodology to have been an extremely efficient and reliable means of procuring food. The technique employed appears to have been particular to the area, and was practised until relatively recent times. This paper presents oral accounts and an analysis of the function and use of these structures. Comments on the physical characteristics of such arrangements are made and related to a discussion of the formational processes of similar but natural features. This paper supplements an earlier study on the subject by Lewis.

HUNTING WITH HIDES: ETHNO-HISTORICAL REFLECTIONS ON VICTORIA RIVER STONE STRUCTURES

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The remains of distinctive man-made stone structures exist throughout much of the Victoria River District of the Northern Territory. These features were constructed as hunting hides, utilised in trapping birds of prey. Aboriginal accounts reveal the hunting methodology to have been an extremely efficient and reliable means of procuring food. The technique employed appears to have been particular to the area, and was practised until relatively recent times. This paper presents oral accounts and an analysis of the function and use of these structures. Comments on the physical characteristics of such arrangements are made and related to a discussion of the formational processes of similar but natural features. This paper supplements an earlier study on the subject by Lewis.

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While undertaking field work during the late 1980s in the area of the Northern Territory known as the Victoria River District (VRD), the author was shown a number of stone features by local Aboriginal men, who held considerable knowledge of their use. These particular observations were made near the town of Timber Creek. At this time, a second researcher was documenting similar features in other areas of this region. In his article, Lewis (1988) describes these characteristic stone arrangements which relate to a specific resource exploitation strategy. Until recently the distribution of these stone structures appeared to be limited to areas associated with Ngarinman, Ngaliwurru and Bilinara language group territories. It is now evident that the construction and particular use of these stone features was much wider than originally postulated, though as yet still within a relatively small region of Australia (Fig. 1).

Ethnographic information obtained by the author from a number of communities in the VRD confirms the interpretation of these small, low circular features as hawk hunting hides. These observations were made while conducting research in relation to a claim by Aboriginal people, under section 50 (1) (a) of the *Aboriginal Land Rights (Northern Territory) Act* (1976), for land near the Northern Territory town of Timber Creek, and while documenting Aboriginal sacred sites in areas to the west.

Historical accounts and ethnographical sources indicate that trapping of birds and the use of hunting hides were activities practised across a wide area of Aboriginal Australia. The particular construction of the stone hides and the accompanying lure technique described in the accounts of VRD Aborigines was of limited distribution though, confined to the general VRD region. This paper in part attempts to explain reasons why this hunting method fell into disuse, and why hides have so far only been recorded in the Victoria River district.

Oral Traditions About Hides And Their Use

Aboriginal oral histories indicate that the procurement of birds of prey, in particular the black kite, *Milvus migrans* (colloquially known as the chicken hawk), by this method formed a major part of the meat component of the diet of VRD people until relatively recent times. As Lewis notes (1988: 74–78), Aboriginal people throughout this district have extensive knowledge of these stone features and the associated hide hunting strategies. Some older Ngaliwurru and Bilinara have themselves hunted the black kite and others of the hawk family in this way, and a number of younger people remember consuming catches made by their elders. At what date the procurement of birds by this method ceased is uncertain. People born in the mid 1940s recall that such practices were still in use during their childhood. To the west, in Mirriuwung and Gadjerong country, it appears that this practice did not continue far into this century. Major factors leading to the decline of this hunting activity have been access to a ready supply of food in the form of station rations and, more recently, the acquisition of firearms and the establishment of roadhouses. According to Jerry Jones Manjiari (pers. comm. 1987), a Ngaliwurru man residing in a camp outside Timber Creek:

> we can get chicken from Fogarty's Store, and anyway they taste better.

European awareness of the existence of these features dates back to the time of the first explorers in this region. However, it was not until much later that

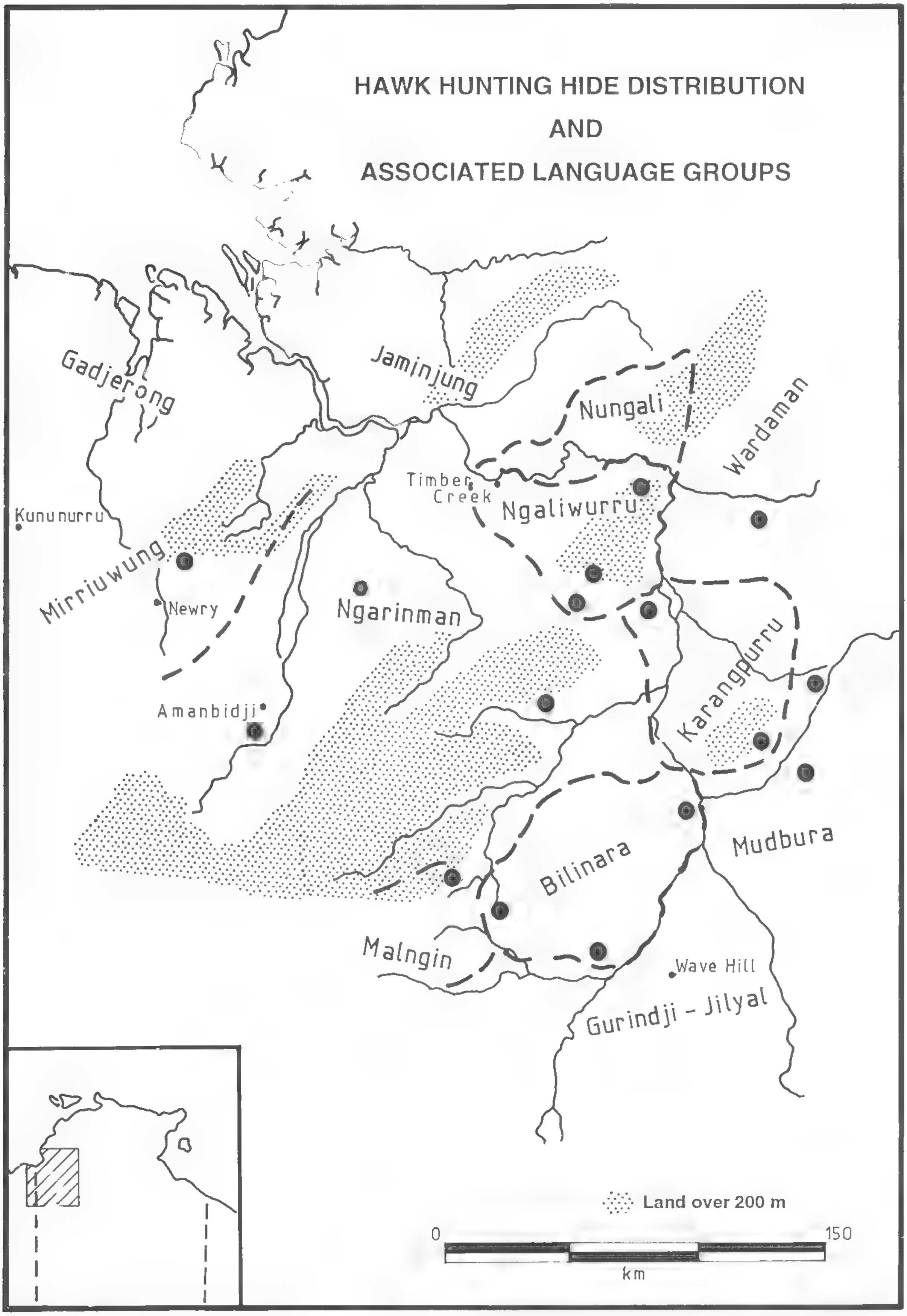

FIGURE 1. Map showing relationship of recorded hide locations and language group territories in the Victoria River District, as identified by the author. Some locations for hides taken from Lewis 1988: 78 (Map 1).

descriptions of these as hides and the associated hunting strategy appeared, albeit to varying degrees (Basedow 1925: 137; Browne 1895: 12; Buchanan 1933: 91; Linklater 1940: 8; Mathews 1901: 77). Judging from the content of their text, it is likely that some of these early accounts were second-hand, the authors having never witnessed the activity, nor spoken to the Aboriginal hunters. Nevertheless, the author's research concerning these features concurs on general principles with these historical accounts, and the consensus as to hunting methods within these texts is reflected in current Aboriginal accounts.

Preparation of the hides entailed the construction of a circular, or semi-circular, low, dry stone wall to a height of approximately one metre. Brush, sticks and loose vegetation (spinifex or other grasses) were laid across the top of the stone structure, forming the roof. One or possibly two men would secrete themselves within, and through a small opening in the roof, would thrust a stick, to which was bound or skewered a small bird. This bird was used as a secondary lure, and was caught with a throwing stick or stones (an activity at which young children are still proficient). Jerry Manjiari stated that a dead bird had the feathers removed, though this aspect of lure preparation has not been mentioned by other Aboriginal informants or in the historical accounts. It is worth noting Mathews' comment that the bait was partially roasted (1901: 77), a variation which has not been confirmed in current oral traditions. The use of small dead birds as lures has been observed elsewhere in Australia, though the employment of a twirling lure seems particular to the VRD. The use of tethered live decoys appears to have been a more common practice (Anell 1960). A fire made adjacent to the hide was the principal lure, the rising smoke attracting hawks and other birds to the vicinity of the hide. It is possible that some of the smoke signals recounted by Willshire in his travels through the VRD bush were these smoky hunting fires (1896: 51).

Accounts given by Jerry Manjiari and Bardi Jalokari suggest that at times two individuals would remain in the hide, one to twirl the lure, the other to catch and kill the attracted birds. Linklater also states that two people worked within the hide (1940: 8). Mirriuwung people also recounted that at times two hunters operated within the one hide. Other informants indicate that the hunting of hawks was a solitary activity, though several hides in close proximity could have been utilised in the one session. Most historical references refer only to one person being within the hide, an accomplice having lit the fire and removed himself from the area (Basedow 1925: 137; Mathews 1901: 77).

The hunter in the hide twirled the rod with the attached bird lure. Jerry Manjiari described the technique as follows (pers. comm. 1987):

> ... [he] rub with the long stick – and make it roll around ... so he's flick flick all the time – they [the hunters] used to keep this one flicking all the time – they can hear this big noise coming up – Ah! – they reckon a hawk coming up – they used to go steady and steady then – they used to pull it right back and they can see him coming right down – they used to pull it right down – he [hawk] try to grab – they used to grab him and pull him down... break his neck... they used to get him – they used fill it right up how much they sit down – they used to go about that much [chest high] they reckon – that's the story they been telling me.

References to a small bird (prepared or otherwise), suspended on a stick rotated by the hunter, are found in the oral accounts of other VRD Aborigines. With the increased, and extended, range of contact between neighbouring and more distant groups in recent times, it is more than likely that some oral traditions concerning this hunting practice have merged. People from different communities state that their knowledge was obtained either as direct witnesses, or from information passed to them as children. There are some obvious local variations; within Mirriuwung country people state that the hunters lay down within the hides, yet in all other areas, people indicate that the hunters sat or squatted. In other aspects the Mirriuwung accounts are strikingly similar, especially the twirling stick lure. Given the consistency in recounting this particular combination of technology by those who once used, or witnessed this method, it appears that the strategy was in general use among a large number of Aboriginal groups throughout the VRD. Unfortunately historical accounts do not elaborate on the matter of particular aspects, or detail. Description are given in general terms, using such phrases as 'exposed to view' (Browne 1895), or 'holding the bait' (Buchanan 1933, Basedow 1925, Mathews 1901). There are further references to small lizards or lumps of meat being placed either beside the hide, or on its roof (Anell 1960: 30–35; Buchanan 1933: 91; Mathews 1901: 77), but Aboriginal tradition suggests that a small bird attached to a stick was favoured as a lure.

The strategy was a successful and efficient hunting method. All accounts attest to the large numbers of birds caught in this way. In addition to hawks, other birds including crows and eagles, attracted by the smoke, were taken. The author was told that the hunting of hawks was undertaken with the certainty of obtaining meat. Obviously, after the initial construction of the stone walling, these structures could be reused. Minimal effort was thus required to procure the birds. This aspect of hide efficiency was stressed by Jerry Manjiari (pers. comm. 1987):

> that's where they used to get their food from – quick one – quick one to get him – you might find you go out hunting for kangaroo – sometime bad wind – wind blowing everyway – you got to have mud on you – well this one is quick way – for hunting food – just like getting chicken in the shop you know.

FIGURE 2. Maggie John (second from right) and other Mirriuwung women standing beside the remains of a hawk hunting hide, Newry station, N.T.

A similar sentiment was expressed by a Mirriuwung woman (Maggie John pers. comm. 1992), while we were inspecting one of these hides (Fig. 2):

> when they bin getting kangaroo nothing – come here – make him fire – get bird – 'nother one comes down get him – soon get big mob – walk back to camp, biggest mob tucker.

It is apparent from the oral tradition among the people of this part of the Northern Territory that they regarded the hunting of fowl by these means as an optimal strategy. Not only young hunters, but older, less agile men participated in the capturing of birds, bringing them back to camp by the armful. The procuring of meat in this manner required fewer skills than those for other hunting activities; all that was needed was a bait and some dexterity in grabbing birds. But while oral accounts suggest that hawk hunting by this technology was an important contribution to the subsistence economy, commentators on hunting and gathering technologies have tended to play down the success of this simple hunting methodology. In his thesis on hunting and trapping techniques employed throughout Oceania, Anell (1960: 51) regards the capturing of fowl by hand as inferior to other techniques generally employed in Melanesia:

> ... [Oceanic peoples] make use of other and more reliable methods which are wholly or in part lacking in Australia, eg. hunting with bow and arrow, snares, bird-lime and pole-nets, ... no time was wasted on the more uncertain and more time-consuming methods in practice of which the Australians have developed such mastery.

It is clear that knowledge of the technique, the location of hides, and oral traditions relating to the practice in the VRD, still exist. People retain many stories associated with the use of these hides; one humorous anecdote (Jerry Manjiari pers. comm. 1987) belies the danger of hunting hawks from hides which are often situated at the very edge of cliffs:

> this story my old father told me – there was him and Konkaman one time – they got into one of these [hides] – and they didn't kill this hawk properly – half dead – they didn't break the neck – they got up you know – he [hawk] was just going every way – he stuck there inside and they said now what we going to do – they just took off – this one old man said oh look you mob buggered everything up for us – because we can't get no more hawks – he went up and growled them – said you mob no good – we can't take you mob next time – that was finished.

Other stories describe dying hawks locking their talons into various parts of the anatomy of the hunters. These occurrences, and reference to other problems

such as lice (Lewis 1988: 76), seem not to detract from present Aboriginal notions of hawk hunting by the hide and lure technique. It is still held in high regard as a sure way of obtaining meat.

Aboriginal men, including Jerry Manjiari and Bardi Jalokari, have discussed these hawk hunting hides with the author. The Ngaliwurru word for the stone structure is *yarungindi*; the technique of twirling the stick was called *patakap-patakap* and *watakum*. Big Mick Kankinang (brother to Bardi Jalokari) however, gave the words *karakurlan* and *kirikirjiti* for the hide structure (Lewis 1988: 75). Further, Lewis termed the small bird lure itself as *perlkan*, whereas Big Mick used the term *djuru* to refer to the same object. It is possible that Big Mick was referring specifically to the small bird used, as the Ngaliwurru word *jura* equates with 'bird'.

One explanation of this variation in terms for the hide and the bait stick may be related to the linguistic properties of transferring naming concepts to English usage. For example, the Garawa of the Northern Territory's southern Gulf country call a flaked stone point *madjadja*. This name may also be given for a quarry site for such artefacts, or for a stone-tipped spear or a stone knife. Quarries may have their own locational title, and spears may be named according to the species of wood used for the shaft. Stone knives may be called *karnjirinya*, this word relating to the hair string and wax of the handle, rather than focusing on the stone blade. Both the word *majadja* and *karnjirinya* are correct names for the stone knife. It is therefore possible that this feature of nomenclature applies also the variation in terms relating to hawk hunting.

This pattern of multiplicity of words, encompassing morphology and/or methodology, is also found among the Bilinara people, whose country commences 80 kilometres south of that belonging to the Ngaliwurru. The Bilinara use the word *ngarunjuna* for the stone hide, and *kungkala* to describe the stick lure. In both instances these are not specialised terms, as *ngarunjuna* refers generally to any hut-like structure, regardless of the materials used in its construction. Loosely translated this word has the meaning of windbreak. Similarly, the term *kungkala* describes the rubbing, twirling motion employed when using the lure, and is the same term used for making fire by the drill method. This pattern of naming is the same as identified with both Mirriuwung and Gadjerong speakers (Kofod pers. comm.).

Distribution

Given the widespread distribution of birds of prey such as kites and eagles, and their behavioural traits in relation to smoke and fires, it is likely that these birds were exploited as a resource in other parts of Australia, though not as successfully as in the Victoria River area. Anell refers to a number of variations on the practice of hunting and trapping birds (1960: 50–51), but there is little in historical accounts, or Aboriginal traditions from other areas, to indicate hawk-hunting on a similar scale to that practised in the VRD area. Writing of the fortuitous shooting of a wedge-tailed eagle in Central Australia by Punch Arrerika (an Aranda tracker), Basedow stated that such birds were highly prized due to the rare occasions that they were obtained (1914: 93–94). A similar sentiment was expressed by a Jingili man (residing in Elliott), who stated the value in finding a fresh carcass of a chicken hawk (Abby Thomas Munamginji pers. comm.).

As stated, the use of stone-walled hawk hunting hides was widely practised throughout the VRD and may have occurred further afield. The ethnographer R.H. Mathews commented that this technology extended south, beyond the Tanami Desert to Lake Amadeus (1901: 76). It is also stated that the northern desert tribes of Western Australia employed similar strategies, utilising hides constructed of spinifex rather than stone (Basedow 1925: 138). There is no tradition of hawk hunting hides among eastern groups extending to the Barkly Tablelands. This is despite feathers of such birds being highly prized, and forming part of ritual paraphernalia in ceremonies. In parts of the Kimberley, including those adjoining Mirriuwung country, there is no record of the use of hides in trapping hawks. As with other fowl, hawks were obtained using a small pronged spear, boomerang, or throwing stick (Kaberry 1939: 14). These hunting techniques are among a wider range recorded by Anell (1960: 28–74), varying in materials and the forms of structures, the lures used, and methods employed in capturing the targeted bird species.

Lewis has identified the distribution of the hides as confined to an area chiefly within the Victoria River Downs pastoral lease, with several outliers (Lewis 1988: 78). However, the evidence of Mirriuwung and Gadjerong people, whose country lies some 150 kilometres to the north-west, is that these features and the associated hunting technology extended over a much larger area than was originally considered. The block-like sandstone, and to a lesser extent the basalt of this region, supplied a handy building material, which facilitated the development of this hunting technology. Knowledge and use of the general principles of this hunting methodology probably extended even further afield. It is likely though, that the combination of circular stone hides with the twirling of the suspended bird lure was a particular, efficient adaptation of the technique in the Victoria River District.

Circular stone features can be found throughout Australia, and many were probably used as hunting hides, most commonly in obtaining macropods. These

FIGURE 3. Carlton Gorge and Ned John (husband of Maggie) seated beside the remains of a hawk hunting hide, Newry station.

FIGURE 4. Jerry Manjiari demonstrating the twirling motion, standing beside a hide situated on an escarpment edge, Stokes Range, N.T.

features rarely show a distinctive form, and many could derive from natural formations. As an archaeological feature though, hawk hunting hide structures are distinctive to the Victoria River Downs region. Most of the hides in the area are constructed from tabular stone blocks (especially in the sandstone country) built to a height approximately level with the head of a seated man (100 cm). The structure is circular and may enclose an area sufficient to accommodate two individuals, plus space to store captured birds. It is estimated that a minimum internal diameter of 100 cm would be required, and more commonly they are in the vicinity of 150 cm diameter. Small, lower, circular stone features in the region are unlikely to have been utilised as bird hunting hides.

The hides were constructed at suitable vantage points where the stone blocks were present. The rugged dissected sandstone formation of the Stokes Range offers these conditions, and is likely to prove rich in hawk hides. Generally, the walls of these structures are one block in thickness (20–30 cm), and smaller stone may be utilised as fill or stabilising wedges. All hides viewed by the author (both by field observation and in pictorial records) do appear to have an entrance, the stone wall not completely enclosing (Figs 3, 4). This explains the 'horseshoe' term used in early descriptions of these features (Browne 1895: 12; Gregory 1884: 115). Even when the wall is partially destroyed or disturbed there remains a relatively clear area devoid of blocks. This entrance feature may therefore be one of the principal diagnostic traits in determining stone structures as hides.

The Stokes Range hides tend to occur near or on the edge of steep inclines, and Ngaliwurru men regard such locations as important in this hunting strategy (Fig. 4). These high and clear vantage points probably maximise the number of hawks attracted by the smoke lures. Elsewhere hides are situated on low stony rises, and in one instance, on Amanbidji Station, the hide is constructed out on the open ground away from the hills (Palmer & Brady 1991: 55). The occurrence of suitable building blocks seems to have been a primary consideration in positioning hides, and if the location also affords high visibility, then this clearly was a bonus. It could be expected that density of hides would increase where a combination of these factors is present.

As mentioned, naturally occurring features do exist which may confuse archaeological patterning. In fact, it is likely that some of the recorded hawk hunting hides are in fact natural features. Such natural stone formations can be found over much of the Stokes Range. They exhibit a number of characteristics which distinguish them from the constructed hawk hide. Akerman has observed (pers. comm.) that large trees may be the predominant cause for these formations. A tree growing in rocky country pushes up and forces out stones from the strata surrounding the trunk. The natural bedding of the strata then tends to slide back on itself, suggesting that artificial stacking has occurred. When the tree dies and decays, or is removed by fire, a characteristic circular stone wall-like structure remains. The floor is usually lower than the surrounding surface with a conical depression representing the area previously occupied by the tree roots. This particular feature is absent in the construction of hawk hides. Further, these naturally created features have been observed in progressive stages of formation.

In addition, one group of stone features recorded as hides, and shown to the author by a Ngaliwurru man, though clearly of human construction are not hides. Also confusing the pattern is the probability that natural formations could be utilised as hides. That this did occur was stated by Mundi, a Mirriuwung man from the Dunham River country, west of Kununurra, in general discussions concerning hunting practices. This man, now deceased, spent much of his time on Ivanhoe Station, and it was evident that he possessed considerable knowledge about these features (Kofod pers. comm.). It is likely therefore, that construction and use of stone hawk hunting hides did extend through western Mirriuwung country, though the only hides seen by the author are to the east, on Newry Station.

Early European Records Of Hides

Although identification of a stone hide is relatively simple, these structures exist in isolation, with no direct evidence that would indicate their function. In fact, without the ethnographic data, their identification as hawk hunting hides is problematic. The earliest records concerning these features were made during Gregory's North Australian Expedition of 1855–56. Gregory noted these stone structures on 1 December, 1855, and surmised from his knowledge of burial customs that they were used as temporary sepulchres (1884: 115). During an unsuccessful search for stray horses the expedition's artist and storekeeper, Thomas Baines, came across one of these hides and noted in his diary (Baines 1856: March 5):

> ... unable to find Gypsey, Polly and several more [,] saw a kind of loose wall and roof built beside a mass of rock and grass strewn in it but no sign of its having been inhabited or to show what use it had been put to.

A few days after this entry he prepared a watercolour sketch (Fig. 5), probably of this structure. His annotation in the bottom right-hand corner indicates that he adduced them to be associated with superstitious practices relating to recovery of health. In his published account Baines was less willing to speculate as to their function, simply stating that they did not

FIGURE 5. Copy of Bains' watercolour sketch of a hide, taken from Braddon 1986: 63. Original held by the Royal Geographical Society, London.

appear to have been put to any use whatever (Baines 1858: 7). Wilson, the geologist attached to the party, suggested that the structures were look-out stations, used when watching for kangaroos (Wilson 1858: 151). It is easy to surmise that the coming of these Europeans into this region would have been an extraordinary occasion, disrupting the regular pattern of subsistence. It is not surprising that members of the Gregory expedition did not witness the hides in use, and were thus unable to correctly interpret their function.

The hides recorded during the Gregory Expedition (1884) conform to the distribution described by Mathews (1901), Basedow (1925), and subsequently mapped by Lewis (1988: 78). This area, within the pastoral leases of Amanbidji, Victoria River Downs and Newry, has been occupied historically by a number of Aboriginal linguistic groups (Fig. 1). Even though the recorded distribution of these hides may be distorted by natural features, it is clear that the practice of hawk hunting with hides and lures occurred over a large expanse of the north-western area of the Northern Territory and part of north-eastern Western Australia, some 18,000 square kilometres in extent. This distribution is far wider than originally postulated by Lewis (1988). It is possible that such features may also occur in areas still remaining to be investigated, such as the country between the Victoria and Fitzmaurice Rivers.

In other regions, in particular that mentioned by Mathews (1901: 76), brush and spinifex would appear to be the only construction materials used, providing a less substantial, temporary structure. Identifying the existence of such features in these regions would be extremely problematic. Inspection of these constructions does not reveal any other material evidence associated with the stone structures. Roofing materials, a few feathers, possibly some blood, and nearby, a small pile of ash or charcoal, are all that would have been left after use. Given that some decades at least have passed since their use, it is unlikely that such material remains in evidence. In fact only one of the hides so far recorded still retains roofing material (Lewis 1988: 77). It is possible though, considering recent developments in the analysis of blood samples on ancient stone artefacts (Loy 1987), that traces of hawk (or human) blood could be detected. Nonetheless, interpretation would still remain inconclusive without the ethnographic data.

The Decline Of Hawk Hunting

It appears that the use of hawk hides ceased about 35 years ago, although in Mirriuwung and Gadjerong country the technique is said not to have been practised by the current oldest generation. This would place the decline in hawk hunting in this western area

of hide distribution at about 1910. Although Kaberry's (1939) accounts indicate that hides were not in use at the time of her research (1935), it is possible that the Mirriuwung man, Mundi, used the technology (Kofod pers. comm.). This would mean that in some areas of Mirriuwung country the hide and lure technique continued until much later. The varied pattern of continued reliance upon this technique after European contact in the region is possibly explained by local differences in attitudes towards Aboriginal people on stations throughout the region. While the establishment of the pastoral industry in region from the 1880s exerted a similar effect on local Aboriginal populations at a gross level (McGrath 1987, Rose 1991, Shaw 1986), the individual attitudes of particular station managers go some way towards explaining local variations in Aboriginal response and adaptation. Certainly Aboriginal reflections on past station people reveal harsher, less charitable relations in the eastern sector of where these hides occur, encouraging continued reliance upon hawk hunting to supplement the Aboriginal diet.

Other interrelated conditions affected particular Aboriginal responses in communities throughout the region. These factors include the advent of retail outlets following the introduction of a cash economy, the ready availability of food, coupled with the decline of interest in acquiring other hawk products for ceremonial purposes, and the introduction and widespread use of firearms. It is worth noting though, that although the use of rifles has made the hunting of most game far easier, the hide and lure technique remains more efficient for hunting hawks.

Nevertheless, while other traditional foods are often collected or hunted by the various communities in this regions, it is only hawk hunting that has dropped out altogether. There appears to be an acculturated response, acquired from Europeans, which has made hawk and crow flesh repugnant to younger members of those communities. In discussing the trapping of hawks and eagles, Buchanan (1933: 91) remarked:

> ... such meagre and repellent flesh seems hardly worth the trouble. But natives have infinite time and patience and, what is more essential strong digestion.

Such statements reflect the attitude of white station people of that era, and are likely to have influenced Aboriginal people living and working on these stations. Furthermore, in recent times, the use of the cotton or synthetic filling obtained from disposable nappies has largely replaced the use of bird down as body decoration during ceremonial activities. This has removed the necessity for acquiring large numbers of these birds, further contributing to the decline of hawk hunting.

Although hawk hunting has now ceased, knowledge of the specialised hunting technology is still retained by Aboriginal people in the VRD. This landscape is dotted with the characteristic stone hides, used in the development of the particular hunting strategy that was employed from west of Kununurra through much of the Victoria River drainage basin. Indications from Aboriginal sources make it evident that hawk hunting was undertaken to provide meat quickly and without great effort. Now that the flesh and other hawk bi-products, such as down, have modern equivalents which are readily available, the activity has lapsed. Knowledge of the hunting technique is retained, and the stone structures remain, but the incentive to utilise them has declined. The country store now fills their role.

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RADIOCARBON DATES FOR PREHISTORIC OCCUPATION OF THE SIMPSON DESERT

M. A. SMITH & P. M. CLARK

Summary

The radiocarbon dates reported in this paper are the first to become available for human occupation of the Simpson dunefield. They show that Marapadi, one of the small wells (mikiri) crucial for Wangkangurru occupation of the dunefield at the turn of the century, was in use about 2700 years ago.

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The radiocarbon dates reported in this paper are the first to become available for human occupation of the Simpson dunefield. They show that *Marapadi*, one of the small wells *(mikiri)* crucial for Wangkangurru occupation of the dunefield at the turn of the century, was in use about 2700 years ago.

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In this paper we report a series of radiocarbon dates for human occupation of the Simpson Desert and review existing archaeological evidence from the region.

The Simpson Desert, one of the great deserts of the world, consists of an immense dunefield, covering 159 490 km^2. This forms a broad triangle bounded by Lake Eyre to the south, the flood plains of the Finke and Macumba Rivers to the west, Goyders Lagoon and the flood plains of the Diamantina River to the east and the Central Australian ranges to the north (Fig. 1). It is the most arid part of the Australian landmass, with recorded rainfall at less than 100 mm p.a. and both rainfall variability and evaporation at extremely high levels (Anon. 1986). The region is dominated by parallel south-east to north-west trending dunes, 10–20 metres high and often running more or less unbroken for hundreds of kilometres. These are sparsely covered with spinifex (*Triodia basedowii*) or sandhill canegrass (*Zygochloa paradoxa*). Land systems and physiographic features of the Simpson Desert are described in more detail by Purdie (1984) and others (Gibson & Cole 1988). Graetz, Tongway, & Pech (1982) provide an ecological classification of the southern part of the region. Within the Simpson Desert there is a major contrast between pale dunes, rich in clay pellets, in the south-eastern part of the dunefield and the red quartzose dunes that form the greater part of the dunefield (Wasson 1983). Respectively these form the Karanguru and Wongkangurru ecological associations recognised by Graetz *et al* (1982). An important feature of the Karanguru association is the number of large playas within the dunefield (see Fig. 1). Loffler & Sullivan (1979) argue that these are remnants of a formerly much larger Lake Eyre whose boundaries are now obscured by dunes.

The southern part of the Simpson Desert was the territory of the Wangkangurru people, whose only permanent source of water was provided by a series of deep wells, called *mikiri*, which tapped subterranean water in shallow sand or gypcrete aquifers. With Wangkangurru guides, David Lindsay entered the heart of the dunefield in 1886 (Lindsay 1886, 1890) but Europeans did not successfully traverse it until the late 1930s (Madigan 1946; Colson 1940). The last of the Wangkangurru left the desert in the summer of 1899–1900 (Hercus 1985) but have provided detailed oral accounts of life in the *mikiri* country, its cultural geography, and of how people came to leave the desert. (Hercus 1985; 1989, 1990; Hercus & Clark 1986).

Fieldwork in 1990

The radiocarbon dates reported here (Table 1) are the first to become available for human occupation of the Simpson dunefield.

Following on from earlier archaeological reconnaissance in the dunefield (Hercus & Clark 1986), we were able to collect small samples for radiocarbon dating from intact hearths eroding at several sites in the Simpson Desert. Our aim was to begin the process of building a chronology for human occupation in the region. Previous work in the region (Hercus & Clark 1986; Davidson 1983) has relied on artefact typology to give an indication of the order of antiquity of occupation but work in adjacent regions (Smith, Williams & Wasson 1991; Veth, Hamm & Lampert 1990) suggests that this approach can lead to gross underestimates of age when compared to subsequent radiometric dating.

In isolation, radiocarbon dates for individual hearths are of limited value. Because of this the fieldtrip in July 1990 also aimed at determining whether key *mikiri* sites had sufficient stratified deposits to provide the basis for a more detailed look at their prehistory. This was found to be the case and it is hoped that a detailed study of two *mikiri* sites, *Marapadi* and *Palkura*, can be undertaken in the near future.

FIGURE 1. The Simpson Desert and places mentioned in the text. Playas and claypans within the dunefield are highlighted in black. Triangles mark archaeological sites mentioned in the text.

FIGURE 2. The broad well depression at *Marapadi*. View looking east, July 1990, with (from L-R) Luise Hercus, Bingee Lowe and Lockey Stewart. (M. A. Smith).

Mikiri wells

There were at least 18 *mikiri* wells in the Simpson Desert. These were the only permanent source of water in the region and were crucial for Wangkangurru occupation of the dunefield at the turn of the century. The most important historical account of the Simpson Desert wells and of the Wangkangurru *mikiri-nganha* people camped near them comes from Lindsay (1886). There is further information in Horne & Aiston (1924). The way of life of the *mikiri-nganha* has been described elsewhere by Hercus (1985, 1989, 1990; Hercus & Clark 1986).

How long the Wangkangurru have inhabited the Simpson Desert is unknown. Linguistic evidence suggests that the time necessary for the separation of Wangkangurru from Arabana, spoken to the south and southwest of the Simpson Desert, is within a thousand years (Hercus & Clark 1986:62). One thing is certain, the *mikiri* are the key to reconstructing the human prehistory of the Simpson Desert. The strategic role of these wells in local subsistence means that any evidence of changes in the pattern of occupation at these sites will have important implications for the prehistory of the southern part of the dunefield.

Marapadi

Marapadi or Murraburt is the westernmost of the *mikiri* wells (Fig. 2). Archaeological evidence of habitation is more extensive here than at the other wells so far visited. The most clearly defined of a series of hearths visible at this site was one (MPI/1) exposed in a deflated area amid a scatter of chipped stone artefacts and finely-fragmented bone on the south end of a dune about 260 m north-west of the well. On the surface MPI/1 (Fig. 3a) appeared as a charcoal stain, roughly oval in plan, measuring 430 x 560 mm. On excavation it proved to be a well-defined basin-shaped pit, 90 mm deep, dug into a finely laminated yellow dune sand. In cross-section a thin band of charcoal extended downslope representing minor reworking of the exposed surface of the feature. The pit was filled with finely comminuted charcoal. It contained no artefacts, burnt clay or shell but its morphology is clearly that of a hearth rather than a root or burrow (cf. Smith, Williams & Wasson 1991: 180–183). A sample of charcoal from the feature gave an age 2710+/–130 yrs BP (ANU-7683), showing that the *Marapadi* well was in use at sometime between 2450–2970 years ago.

Palkura

At *Palkura*, unlike *Marapadi*, archaeological material is concentrated within the broad depression of the well itself. Occupation debris is only sparsely scattered elsewhere. About 300 m southwest of the well, we found a hearth (PKA/1) eroding from sediments at the foot of a dune. It consisted of a patchy scatter of charcoal lumps over a roughly circular area 600–800 mm in diameter. Upon cleaning back the surface with a trowel much of this proved to be charcoal thrown out from a well defined fireplace (Fig. 3b). The latter was about 450–500 mm in diameter and consisted of a dense charcoal stain with large lumps of wood charcoal, up to 10 mm in diameter. This lay in a shallow basin, 70 mm deep, dug into a fine weakly laminated yellow dune sand. Although there was a thin scatter of chipped stone and finely fragmented animal bone on adjacent surfaces,

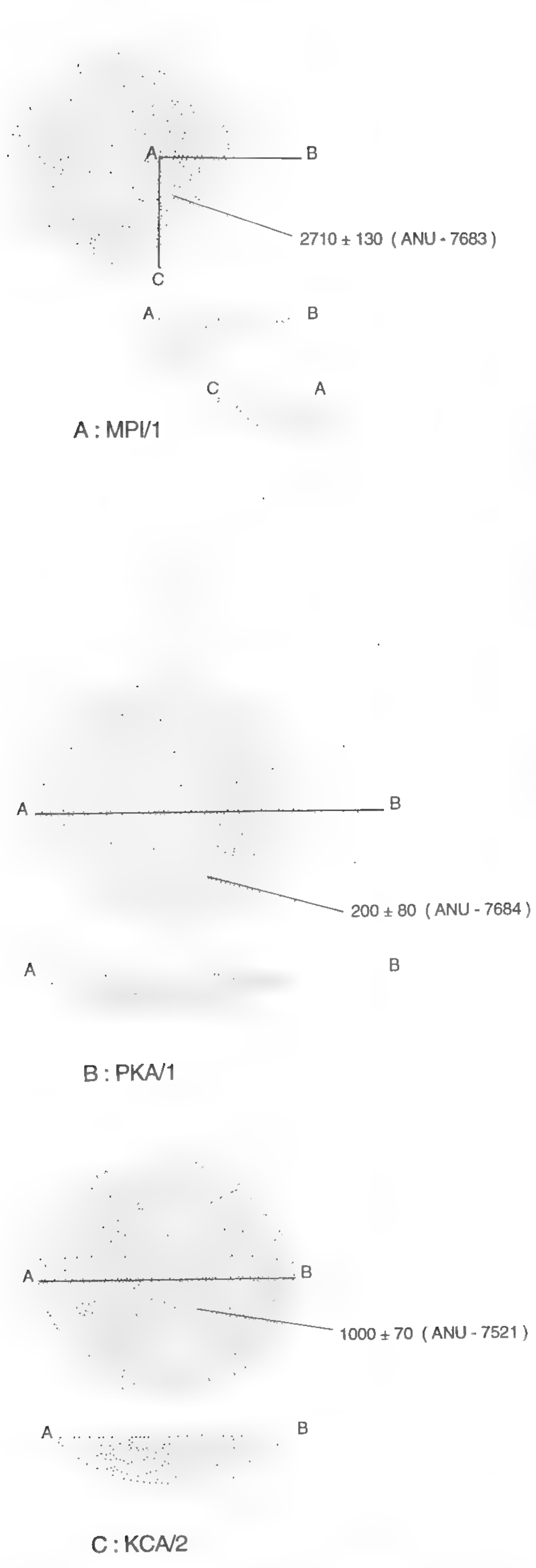

FIGURE 3. Plan and cross-section of excavated hearths.

there was no archaeological material apart from charcoal within the feature. A radiocarbon date of 200+/–80 yrs BP (ANU-7684) indicates that this hearth may date to the last phase of use of *Palkura* by Wangkangurru people.

A second feature, situated on the dune east of the well, was cross-sectioned but its distinctive cylindrical, slightly tapering, cross-section identified it as a tree-root rather than a fireplace (cf. Smith, Williams & Wasson 1991: 183).

Kadlalumpa

Kadlalumpa is one of the eastern group of *mikiri* wells. Amongst other archaeological material at this site there were four hearths eroding out in various parts of the site (eg. Hercus 1990 Fig. 2). One of us (PC) collected a sample from a hearth, labelled K4, on a separate visit in 1987. This was not necessarily the best preserved of the hearths but was sampled because its position with respect to the internal stratigraphy of the dune seemed to imply some antiquity. A sample of burnt sand and finely comminuted charcoal from K4 (ANU-7199) was submitted to the ANU Radiocarbon Laboratory but proved insufficient for dating. Although undated, the K4 hearth is of interest for its unusual morphology. In cross-section, there was no discernible vertical shape rather it formed a thin baked pavement or crust about 10 mm thick. The vesicular structure of this crust and the presence of baked clay and finely disseminated charcoal suggest that K4 was a fire constructed directly onto the soil surface at a time when this was slightly damp.

Other sites in the dunefield

Kuncherinna

One other site was sampled during the 1990 trip. This was at *Kuncherinna* where a series of hearths appeared to be eroding from a dune core, from buff sediments underlying a reddish palaeosol.

The *Kuncherinna* site borders a large claypan (Fig. 4). On either side of the claypan there are high longitudinal dunes. On the lower slopes of these there is a thin scatter of chipped stone artefacts which includes tula adzes. On the western side of the claypan, we noted eight hearths eroding from dune sediments. Two of these (labelled KCA/1 and KCA/2) were sectioned.

KCA/1 was manifest as a roughly circular patch of diffuse charcoal and baked earth, about 1.2 m in diameter. In cross-section it was a thin lense of charcoal-stained baked earth, 20 mm thick, with the vesicular structure familiar from the *Kadlalumpa* hearth. It contained some large pieces of charcoal, up to 15 mm diameter, but otherwise had no internal structure and contained no other occupation debris. As for the *Kadlalumpa* hearth, KCA/1 is probably the

FIGURE 4. Aerial view of the Simpson Desert at *Kuncherinna* showing the large claypan and longitudinal dunes. View looking south-east, July 1990. KCA/1 and KCA/2 were situated on the western margin of the claypan, at the lower left of the photograph. (M. A. Smith).

remains of a fire lit directly on the surface of damp soil. Charcoal from this feature was radiocarbon dated to 1250+/–160 yrs BP (ANU-7520).

KCA/2 (Fig. 3c) was a small sharply defined fireplace in a basin shaped depression about 450 mm in diameter and 90 cm deep. This was dug into the surface of an indurated pale yellow clayey sand, topographically below a reddish palaeosol. It contained abundant large pieces of charcoal as well as finely comminuted charcoal. Charcoal from this hearth gave a radiocarbon age of 1000+/–70 yrs BP (ANU-7521), a result which overlaps with ANU-7520 if these dates are taken at two standard deviations.

These results indicate that the hearths at the *Kuncherinna* site are dug into the eroding surfaces of the dunes rather than contained within the Pleistocene sediments. The closely comparable ages obtained from two hearths situated at least 100 m apart raises the possibility that the remains at *Kuncherinna* record a single occupation, or closely spaced occupations, rather than an accumulation spanning several millennia. Further dating of hearths would be necessary to establish whether this is indeed the case.

Dated sites on the margins of the Simpson Desert

Although some archaeological reconnaissance has also been carried out in the northern part of the Desert, near the Toko Ranges by Davidson (1983) and at Geosurveys Hill by N. B. Tindale (Anon. 1962), the only other radiocarbon dates presently available for occupation of the Simpson Desert are from the western and north-western margins of the dunefield.

Oolgawa waterhole

During a geomorphic study of the Simpson Desert, R.J. Wasson identified several hearths exposed in the northern end of a longitudinal dune (Stockyard Dune) where it encroached upon the active floodplain of Adnalgowara creek (Wasson 1986: 63; Wasson, pers comm.). Charcoal from the hearths gave radiocarbon dates ranging from 2000–3000 years BP (Table 1). By chance the South Australian Department of Mines sampled the same features and obtained closely comparable radiocarbon dates ranging from 2500–2700 years BP. These dates serve to demonstrate use of productive flood plain habitats (Macumba ecological association) on the western margin of the dunefield at about the same time as we have evidence that *Marapadi* was in use.

Therreyererte

Therreyererte is a large open site on an alluvial fan on the northern edge of the Rodinga Range. The latter is a bold sandstone range rising abruptly from the dunefield in the north-western part of the Simpson Desert, dividing a small outer dunefield of about 1500

TABLE 1. Radiocarbon dates for sites in the Simpson Desert. Dated material was charcoal from hearths, except in the case of *Therreyererte* where detrital wood charcoal from an archaeological deposit was dated.

Site	Feature	Sample Code	Conventional Radiocarbon Age (years BP)	Reference
Marapadi	MPI/1	ANU-7683	2710+/-130	this paper
Palkura	PKA/1	ANU-7684	200+/-80	"
Kadlalumpa	K4	ANU-7199	small sample	"
Kuncherinna	KCA/1	ANU-7520	1250+/-160	"
Kuncherinna	KCA/2	ANU-7521	1000+/-70	"
Oolgawa WH		ANU-2838	1900+/-200	Wasson pers. comm.
"		ANU-2836	2220+/-100	"
"		ANU-2837	2840+/-80	"
Therreyererte	Z90/6	SUA-2520	400+/-50	Smith 1988
"	Z90/10	SUA-2519	1830+/110	Smith 1988

km² from the main body of longitudinal dunes. A small excavation at this site in 1986 (Smith 1988: 292) revealed a stratified occupation deposit underlain by red aeolian sand. The occupation is dated at two points by radiocarbon samples to 400+/–50 yrs BP (SUA 2520) and 1830+/110yrs BP (SUA 2519). By extrapolation, the basal age of the occupation deposit is about 3000 yrs BP at this site. This again suggests some parallel with the radiocarbon date for *Marapadi* but it is worth noting that the major period of use of *Therreyerte* did not begin until about 570 yrs BP.

Discussion

The radiocarbon dates reported in this paper are the first step towards establishing a chronology for human occupation of the Simpson Desert. They show that at least one of the *mikiri* wells was in use about 2700 years ago. This has implications for the prehistory of the region. Firstly it suggests that the locations of some of the Simpson Desert wells were known at this time. Secondly, it indicates that the shallow groundwater tapped by the *mikiri* wells existed at this time. Thirdly, if current views on the nature of these shallow aquifers are correct, it points to the likely availability of such groundwater earlier in the Holocene. As the *mikiri* tap groundwater supplies directly recharged by rainfall in this part of the dunefield they are presumably sensitive to long-term changes in regional rainfall. Given that the period around 3000 BP was the driest phase of the Holocene (Singh 1981; Singh & Luly 1991), it is possible that shallow groundwater would have also been locally available as early as 6–7000 BP. Whether or not humans occupied the dunefield at this time is unknown but in this context it seems likely.

The date of 2700 yrs BP for *Marapadi* also seems to coincide with evidence of use of the extensive floodplains on the western margins of the dunefield and the first phase of use of *Therreyererte* in the north-western part of the dunefield. Whether the apparent visibility of sites at this time is simply fortuitous, whether this was a short-lived period of greater human activity in the region or whether it marks the beginning of more intensive use of the major dunefields along the lines suggested by Veth (1989) will require more evidence to determine.

While it might be tempting to see the evidence from *Marapadi* as reflecting a broadly similar pattern of occupation of the dunefield to that recorded for the Wangkangurru at the turn of the century, the limited nature of the evidence prompts caution. Isolated radiocarbon dates on hearths and fireplaces cannot tell us whether use of the wells at this time was more, or less, itinerant than that recorded historically, nor whether use of the wells continued without major interruption from 2700 yrs BP until 1899–1900. Fortunately the presence of apparently stratified occupation deposits at some *mikiri* sites, together with an abundance of faunal remains and imported stone provide an opportunity to investigate prehistoric use of these key wells and the subsistence activities and external contracts of the desert Wangkangurru.

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The authors thank Linda Crombie (Birdsville) for her support and the Aboriginal Heritage Branch (Department of Environment and Planning, South Australia) for formal permission to collect radiocarbon samples from archaeological sites in the Simpson Desert. Further information on the *mikiri* and *Kuncherinna* sites is held in the site register maintained by the Aboriginal Heritage Branch. We also wish to thank our companions in the field; Luise Hercus, Vlad Potezny, Bingee Lowe (Finke) and Lockey Stewart (Hamilton). The assistance of Vlad Potezny in relocating the *mikiri* sites was crucial to success of the fieldwork reported here. R.J. Wasson generously supplied information on the radiocarbon dates from Oolgawa waterhole. We thank Luise Hercus, Roger Luebbers, Mike Morwood, Vlad Potezny, Peter Veth and Bob Wasson for commenting on an earlier version of this paper.

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'THE INHABITANTS OF COOPER CREEK' : A PART TRANSLATION OF CARL EMIL JUNG'S 'AM COOPER CREEK'

C. W. NOBBS

Summary

This paper provides an introduction to the writings of Dr. Carl Emil Jung who travelled widely in Australia between 1865 and 1876. He then returned to Germany and published many works largely on the European colonies in Australia and the Pacific region. Particular reference is made to his writings on the Aborigines of South Australia. The paper includes a translation from Jung's article 'Am Cooper Creek' (1878), an account of his contact with the Aborigines on the Cooper Creek in 1865.

'THE INHABITANTS OF COOPER CREEK': A PART TRANSLATION OF CARL EMIL JUNG'S 'AM COOPER CREEK'.

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NOBBS, C. W. 1993. 'The Inhabitants of Cooper Creek': A part translation of Carl Emil Jung's 'Am Cooper Creek'. *Rec. S. Aust. Mus.* **26**(2):129–138.

This paper provides an introduction to the writings of Dr. Carl Emil Jung who travelled widely in Australia between 1865 and 1876. He then returned to Germany and published many works largely on the European colonies in Australia and the Pacific region. Particular reference is made to his writings on the Aborigines of South Australia. The paper includes a translation from Jung's article 'Am Cooper Creek' (1878), an account of his contact with the Aborigines on the Cooper Creek in 1865.

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Carl Emil Jung's Writings On The Aborigines Of South Australia

By 1860 the colony of South Australia was well established, and had a large German population living in and around Adelaide. Reports from the German communities about their successes, particularly in the acquisition of land and new freedoms, and about their isolation, were sent back to Germany to urge friends and relatives to join them in South Australia. By the end of the nineteenth century approximately 18 000 Germans had emigrated to the colony. Mainly consisting of farmers, tradesmen and their families, they also included a small number of professional people (Harmstorf 1976: 35):

> Most of the professionals were pastors and missioners of the Lutheran Church, but around the year 1848, with its abortive liberal revolutions in various parts of Europe, including the German states, came a sprinkling of men who for want of a better term may be called intellectuals, men who had received some form of tertiary education in Germany.

Dr. Carl Emil Jung, who had received a Doctor of Laws degree from either Göttingen or Jena University and travelled to South Australia in the late 1850s, was one of these 'intellectuals'. The earliest record of Jung's activities is his account of the time he spent as a manager of stock on the Dewalla Creek in south-western Queensland in 1865. Very little is known of his movements over the following seven years. In 1872 he was resident in Tanunda, South Australia, and applied for a licence to work there as a teacher.[1] He had the support of 'well educated' Germans like Martin Basedow, who has been described as 'an outspoken advocate of what was called "progressive education" at the time' (Harmstorf 1975). Basedow served briefly as the South Australian Minister for Education and was also the proprietor of Australia's largest German newspaper, the *Australischer Zeitung* ('Australian Newspaper').

In January 1873 Jung was appointed French Master and Assistant in the Boarding House at the Church of England Collegiate of Saint Peter in Adelaide, and in December accepted a German Professorship there.[2] He resigned in April 1874 upon appointment as Inspector of Schools in South Australia. This gave him the opportunity to travel to all parts of the state. He resigned from this position in December 1876, and soon after returned to Germany. The *Neu Deutsch Zeitung* ('New German Newspaper') of January 1876 reported that (p.4):

> Our fellow countryman Dr. C. Jung has given up his position as School Inspector because family matters compel him to travel to Europe. Dr. Jung, as we hear it, intends to familiarise himself with the new education system during his stay in Germany and to utilise the results of his research upon his return to South Australia.

Jung did not return to South Australia. During the following years though, he wrote many articles and several books on the European colonies in the Pacific region. Jung published three works based specifically on his contact with the Aboriginal people of South Australia.

Soon after his return to Germany Jung published 'Zur Kenntnis südaustralischer Dialekte' ('Towards a Knowledge of South Australian Dialects') in the *Journal of the Geographical Society of Leipzig* (1876). The title suggests an early analysis of the dialects of the South Australian Aboriginal people, but the article is not yet available in Australia. Two further accounts of his contact with the Aboriginal people of South Australia were published in the *Journal of the Geographi-*

[1] Records of the Central Board of Education, 1872: No. 50. Entry No. 2083, GRG 18, State Records Office.

[2] Minutes of the Council of Governors, the Church of England Collegiate of Saint Peter, Adelaide, 8 December 1873.

cal Society of Halle. The first article, 'Die Mündungsgegend des Murray und ihre Bewohner' ('The Murray-mouth Region and its Inhabitants') appeared in 1877 (1877a), followed by 'Am Cooper Creek' ('On the Cooper Creek') in 1878. These were based on first-hand observations, supplemented by information from the missionary George Taplin and, possibly, the police-trooper Samuel Gason.

In 1877 Jung also delivered a short paper titled 'Schamanismus der Australier' ('Shamanism of the Australian Aborigine') to the Anthropological Society of Berlin in which he described the role of magic in the beliefs of the Diyari people of the Cooper Creek. This appeared in the *Proceedings of the Anthropological Society of Berlin*, (1877b) and was also published in *Ethnological Journal* in Berlin. Another article 'Aus dem Seelenleben der Australier' ('From the Spiritual life of the Australian Aboriginal') published in the *Journal of the Geographical Society, Leipzig* (1877c), is not yet available in Australia.

In the same year, Jung also published two articles in *Globus*, an illustrated journal for 'Länder and Völkerkunde' ('Lands and Ethnology') which gave particular consideration to articles by specialists in anthropology and the ethnology of different countries. 'West Australien. II. Die Ureinwohner' ('Western Australia. II The Aboriginals', 1877d) is an ethnography of the Western Australian Aboriginal people in which Jung gave a detailed description of the people who lived in the north and south of the state. This included details of their housing, clothing, utensils and weapons, foods, social organisation and religious beliefs. He visited the prison on Rottnest Island which held 67 Aboriginal prisoners, many of whom had killed someone under tribal law and were subsequently incarcerated.

At the time of Jung's visit to the Catholic Mission of New Norcia, which was under the administration of Bishop Calvado, 34 Aboriginal adults and 26 children were living there. They were taught to read and write and given instruction in Christian beliefs with mixed results. Jung noted for example, that the Aboriginal residents believed that eating and drinking epitomised the way to salvation, as signified by the images of full-bodied angels, whom they said 'always had a full stomach'. They also heard parables from the bible and understood them literally: sheep went to heaven for example, but it was not clear why their animals (the emu and the kangaroo) were not to enjoy the same good fortune (Jung 1877d: 346–356; 365–367).

'Die Zukunft der Australischen Eingeborenen' ('The Future of the Australian Aborigines', 1877e) described the plight of Aboriginal people in each state and the various government policies and attitudes towards them at the time. Jung began by noting the lack of interest from official circles in getting to know the languages, customs and habits of the Aboriginal people. He acknowledged the importance of records left by the missionaries, the accounts of travel by explorers which reported their contact with the Aborigines in different regions, and also the detailed and reliable reports about Aboriginal tribes in the east, south and west of the country which came from the settlers and visitors to this land. By comparison, wrote Jung, the governments in each state had taken no steps to use people knowledgeable in ethnology to collect reports on the fast disappearing Aboriginal tribes. He noted approvingly that at least two colonial governments had taken the matter in hand. South Australia's Governor, Sir Anthony Musgrave (Jung 1877e: 219–222), had expressed the urgency of collecting:

> as quickly as possible, information about the languages, traditions and customs of the existing tribes, before they disappear from the earth as they have in other regions.

Jung also mentioned the establishment of a commission in Queensland with the purpose of investigating the position of the Aboriginal people and the possibility of 'civilising' them. The commission included the well-travelled explorers A. C. Gregory and W. Landsborough, as well as Bishop Hale who had already worked extensively among Aboriginal people in South Australia (Jung 1877: 235–237).

In 1879 Jung published 'Australien und Neuseeland' ('Australia and New Zealand'), an historical, geographical, and statistical sketch with 10 illustrations. In the introduction to the first edition of this book, Jung stated that 'the Australian colonies had in recent times aroused a lively and justifiable interest'. During the preceding ten years the large-scale migration to countries about which the Germans had little, if not out-dated knowledge, created a desire for more precise and current information. Their best geography text books were inadequate and geographic magazines did not provide the whole picture. Jung believed he could correct this deficiency and explained his purpose, using the third person (Jung 1879: iii–iv):

> It is the intention of the author to publish a comprehensive work on the Australian colonies. As a result of the participation of the German Reich in the International Exhibitions held in Sydney and Melbourne, a lively interest has been generated amongst many Germans who express the wish to obtain an up to date knowledge of the regions where it is hoped German industry can win a respectful place. In short, it appears advisable to draw up as quickly as possible, in a comprehensive way, sketch plans of existing conditions in those colonies.

The author's main purpose has been: to describe the economic conditions of the land at this time, as completely and objectively as possible in the limited space available. That is why he has allocated only limited room to the chapters on geography and ethnography. Instead he hoped to give the statistical data the desired comprehensiveness.

His stay in Australia extended over 19 years, and many times he travelled in all the colonies, almost to

the heart of the continent. For several years he was in a responsible position as government officer. This experience enabled him to obtain a detailed knowledge of the land and its inhabitants.

In this fact-filled publication Jung described the discovery and settlement of Australia and New Zealand, their physical features, and included chapters on their industries and populations.

Jung's comprehensive work 'Der Weltteil Australien' ('The Australian Continent') was published during 1882–1883 in four parts, as volumes VI, VIII, XI and XII of a series titled 'Das Wissen der Gegenwart' ('The Knowledge of the Present'), published by the German Universal Library for Education. Jung's volumes offered a broad perspective on geographical features and the impact of settlement in the region and included detailed information on the native peoples of the Western Pacific and Australia. Two of these illustrated volumes included ethnographic detail on Australian Aborigines: Part 1 (Volume VI), 'Der Australcontinent und seine Bewohner' ('The Australian Continent and its Inhabitants'), and Part 2 (Volume VIII), 'Die Kolonien des Australkontinents und Tasmanien. Melanesia.' ('The Colonies of the Australian Continent and Tasmania. Melanesia.'). Parts 3 and 4 (Volumes XI and XIII) were devoted to Melanesia, Polynesia (including New Zealand), and Micronesia. An abridged version of the complete work also appeared in English, published by W. Swan Sonnenschein in London in 1884.

Jung wrote two articles, both under the title of 'Deutsche Kolonien' (German Colonies) published in 1884 and 1885. The first was described as 'an article to improve the knowledge of the life and work of our fellow countrymen or "Landesleute" on the land in all continents' (Ferguson 1941–69: 190). The second made 'particular reference to the newest German acquisitions in West Africa and Australia [sic]' (Ferguson 1941–69: 190). Jung's 'Australie en Tasmania' ('Australia and Tasmania') was also republished in a Dutch edition in 1885. This would seem to be a translation of Jung's publication of the same title from 1882–83.

Jung's ethnographic writings reflect the dominant influence of his geographic studies. He was prepared to attribute the major differences which he observed between Aboriginal groups to geographic factors. In his introduction to 'The Murray Mouth Region and its Inhabitants' (Jung 1877a), he wrote that 'the characteristics of Aboriginal people are essentially limited by their geographical position and the productivity of the land' (Jung 1877: 24–47). He cited the examples of the Aboriginal people of Eyre Peninsula who were of a 'crooked stature', and the Aborigines of the drought-stricken plains of Western Australia who lived in a 'wretched state'. To these he contrasted the Aboriginal people of the Murray River who profited from an abundant supply of fish.

Jung went on to describe the geography of the Murray Mouth region, then provided an ethnography of the Narrinyeri people who lived there. A map showed the location of the Mission, the small towns to the north and the 18 clans of the Narrinyeri. His occupation as Inspector of Schools had enabled him to visit the area several times and to meet the Reverend George Taplin at the Point Macleay Mission. Jung's description of Narrinyeri customs and religious beliefs was largely based on Taplin's work. Whilst he acknowledged the importance of Taplin's records and oral information, Jung claimed that his own observations led him to different conclusions. For example, he included a Narrinyeri grammar in the article, but argued that Taplin's description of the language as very highly developed had been unwarranted.

Jung's 'On the Cooper Creek' was published in four parts, dealing with the Geography, Plants, Animals, and Inhabitants. Jung gave a detailed description of the peculiarities of the geography, flora and fauna in the region and changed to a narrative style in the fourth part to describe his contact with the Aboriginal people of the area. This account, as translated below, included descriptions of the Aborigines' clothing and decorations, and a rain-making ceremony. The similarity of these descriptions to the observations of Diyari Aboriginal people made by Samuel Gason, a police trooper stationed at Lake Hope in 1864, are remarkable (Gason 1879). Jung's description of the rain-making ceremony is identical both in form and content to Gason's and they both provide very similar descriptions of the Aboriginal people's ornaments. It is difficult to decide whether Jung used Gason as an unacknowledged source or whether his contact with the Yawarrawarka and Yandruwantha people near Innamincka, revealed distinct similarities in dress and custom.

Jung's description of the Aborigines of Cooper Creek was one of the earliest to be recorded, coming as it did just three years after the Burke and Wills expedition had failed there. Alfred Howitt's initial account of the Aborigines of the region, recorded during the Burke and Wills Relief Expedition, was not published until 1878, the same year as Jung's publication. It is likely that Jung's account, published in Germany, added further encouragement to German missionary interest in Central Australian Aborigines, as already expressed in the foundation of Lutheran missions at Killalpaninna (1866) and Hermannsburg (1877). His work would have been read widely in academic circles and no doubt by Erhard Eylmann, a German doctor with an interest in 'Anthropogeographie'. Eylmann made several visits to Australia between 1896 and 1902 and published the results of his anthropological research in the classic 'Die Eingeborenen der Kolonie Südaustralien' ('The Aborigines in the Colonies of South Australia', 1908). Eylmann was certainly familiar with Jung's writings

on the Australian Aborigines and these may in fact have provided a direct impetus for his work.

'The Inhabitants Of Cooper Creek'

It was an unusual occasion that brought me to this region. Today the land is fully occupied, surveyed (though in a rough way) and leased to pastoralists who appear to make good business there. In those times the Cooper Creek was a goal reached only by explorers. It was better known than many other rivers nearby, for the tragic fate of Burke and Wills had vested it with lasting interest.

I was at the time stationed on the Devalla Creek, south-east of the Wilson River. In those times, the oldest colonists warned of long periods of drought in which all water evaporated, all vegetation spoiled, and both the indigenous and introduced animals perished. I was of the opinion, as were many others, that settlement had overcome this sad phase of existence of the colony. That danger was not to be feared any more, and the squatter pushed irresistibly further and further forwards: at first with herds of cattle, then sheep. The search after grazing places was an occupation, and the sale of such practical knowledge became a source of income for more than one enterprising Australian pioneer. Even though moderate rain fell we still believed that the climate had changed for the better.

The year 1865 destroyed this illusion with a rough hand. The rainfall of the preceding years had been lighter in the inner districts, and now the eternally clear sky, scarcely covered by a cloud, was barren. All the waters dried up, and soon the last traces of vegetation were consumed down to their roots. The bodies of dying stock covered the plains, and the few waterholes became poisoned through their decomposition. In the caves and ravines of the distant mountains the lives of the indigenous animals ended.

The only trading place for this region was Fort Bourke. A German named Becker owned the store, in which everything could be found. There were extensive stores catering for the body's necessities including food and toiletries. The store, to use an expression used commonly by sailors and adopted by the squatters, held everything 'from a needle to a sheet anchor'. Between Becker and I lay a wide wilderness in which only isolated oases remained on the Paroo and the Warrego. These were the location of police stations which also served as post offices to which a small supply of letters and a plentiful supply of newspapers and monthly journals were brought out by dispatch rider from Bourke every 14 days. Otherwise the traffic was closed. Wool, which was sent to Bourke on heavy carts with great danger to the bullockies' lives and with the forbearance of the draft oxen, rotted outside under the sky because the store-owners refused to take it into their warehouses. Then 'cui bono', or 'to what purpose'? The shallow Darling could be crossed over on exposed reefs, and for a long time no steamers had travelled on it. The worth of the wool was less than the cost of overland transport to Sydney.

We were isolated, with only a few neighbours on the Wilson. The waterholes on Devalla Creek began to dry up. The dams built at great cost stood there useless, their reservoirs empty. The question of where to go to save the lives of the cattle and sheep came closer to me every day. To retreat was unthinkable, as the route to the Darling was barren. The only hope lay to the interior. For the 12 000 sheep there was soon a solution. A long deep waterhole on the Wilson, a 'billabong', offered itself to them. But cattle will not stay where sheep graze, and I had to go further. The only place was on the Cooper. A broad waterless stretch of torn black expanses and steep red sandhills lay between the Cooper and our stock. Although the numerous tribes of Aborigines living there would not welcome our arrival with friendliness, the attempt had to be made.

It was made and achieved despite countless difficulties and real danger to life because of water shortages. The animals, frantic with thirst, had almost forced their return to the abandoned waterholes over our bodies. Never will I forget that feeling of escape from extreme danger and the elation that accompanies achievement of a rare and risky undertaking when, on an arduous February night, I discerned in the bright moonlight the dark, dim line which was the Cooper. It was probably the first time a loud and cordial 'hurrah' had resounded through this wilderness. The pad which the camels of Burke and Wills' calamitous expedition had pressed into the soft earth was still clearly visible, and often served as a guide to us. This pad made a melancholy impression on my people and intensified the feeling of our predicament: we could read the story in the signs left behind on the Cooper. Burke and Wills returned to this place from the Gulf of Carpentaria only to become bitterly disappointed. Upon their arrival they found, to their horror, that the camp was deserted. The sombre green leaves and the brown raw bark of the trees, the black furrowed earth, and the deathly stillness all around were passing features and colours of a picture that appeared before our souls. We moved further downstream, and on a marvellous lake-like part of the river erected our camp. Mighty eucalyptus trees hemmed the high southern bank, while on the other side magnificent quartz sandstone outcrops completed the view. The bark of the trees carried the initials of all who had visited the creek before us. Not many, but names well known to Australian history.

We had with us only a small tent and meagre supplies on the pack saddles of our horses. The ground was too rough, and the route too difficult, to have risked taking a wagon. The tent served as our store-

FIGURE 1. Example of a *Thippa*, a decoration made from the tails of the extinct rabbit bandicoot. Collected by R.T. Maurice, Cooper's Creek. A2990, South Australian Museum.

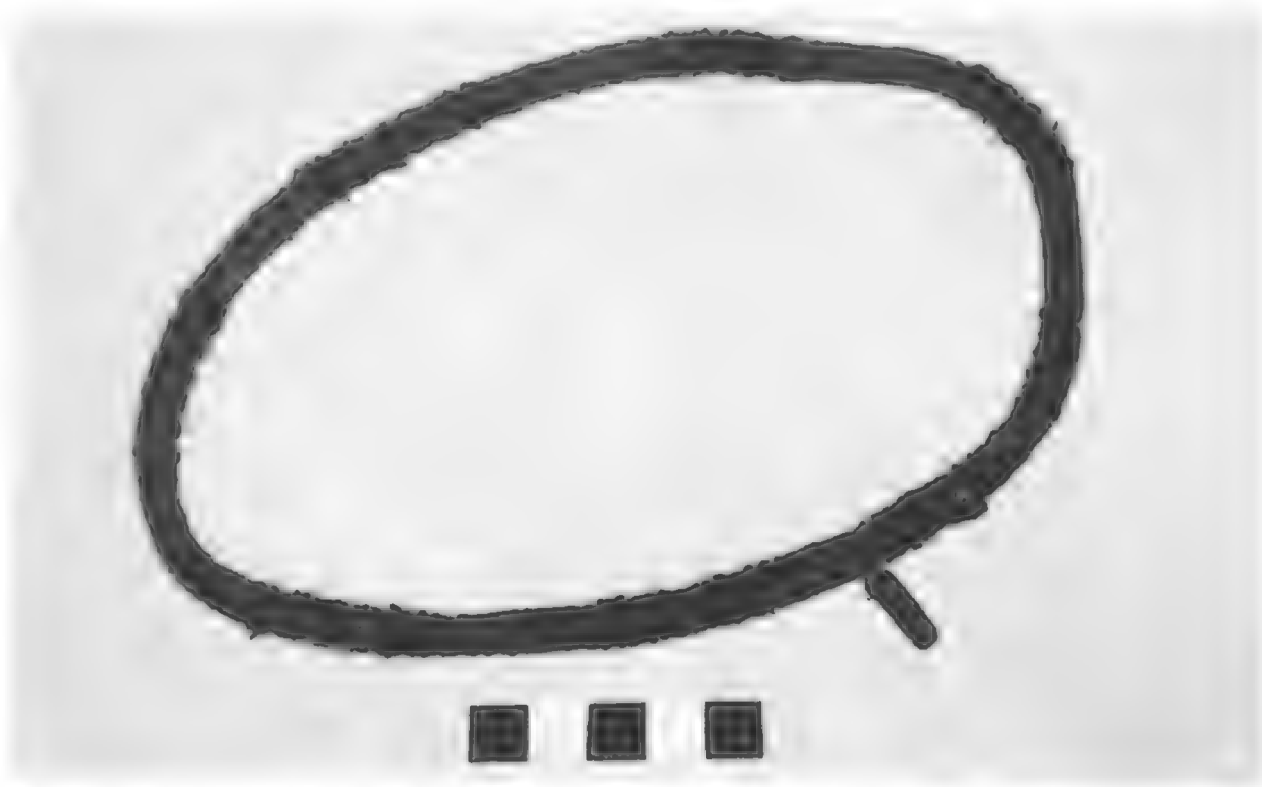

FIGURE 2. Example of a *Mandamanda*, a woman's girdle. Collected by J.G. Reuther, Killalpaninna Mission. A2890, South Australian Museum.

house. The stores were meagre: blankets, clothes, a half sack of flour, a few sacks of sugar, preserved fruit and fish, and some tobacco and matches. The flour was abominable. We had secured it on credit from a settler on the Barcoo. God knows how long it had been stored by him since being purchased from some trader who should have sold it only as pig food. Half of it consisted of maggots. One of the indispensable foodstuffs missing was salt. We crushed enough from an abundant supply in a nearby salt creek, but soon found that it was unusable. The meat from our slaughtered cattle spoiled, and no one liked to eat the salted or 'jerked' beef. But the plentiful supply of meat which we could not handle was not wasted: we were not alone.

Most certainly our arrival had been awaited for some time. The Australian Aborigines were informed of our movements in advance by their peculiar telegraphy using smoke and fire. They were the lawful owners of the hunting grounds which I claimed for my cattle. When we arrived, there was not a soul to see and no tracks betrayed their presence. Yet they were around us, and nightly watched our camp without us seeing their tracks. The bushes which they bound on their feet completely swept away their footprints in the soft ground. My black companions did not want to acknowledge their presence, although they probably perceived much earlier and more easily the crushed Salsolaceen (buckbush or 'rolly-polly') and broken bushes which my assistant, Swanhill Jack, with his reliable skills as a bushman, soon drew my attention to. I gave orders that nobody should go away from the camp at night without first informing me of it. Nevertheless, one of my best men almost fell victim to a bullet from my rifle because of his sin of omission. The next morning showed how closely the Angel of Death had passed over him.

Finally they came. We had meat to throw away, and the blacks were hungry. They did not dare lay hands on our cattle (as they probably would have liked to), because they knew too well the sharp noise of firearms and its significance. They had, without a doubt, heard how the settlers in Queensland took revenge on those who stole their property, and they therefore preferred to come forward at last. Perhaps they were encouraged by the presence of our blacks, who had almost more to fear from them than we did as they had no more right than us to these foreign lands and they were not protected by the 'Nimbus' of superiority with which the white man faces the black man. We slaughtered a young cow and then they came, all eager to get some. First came a few young women, then old men, and, lastly, a whole group. We let everyone take away a gift. It was not hard to satisfy them, as no part of the animal was scorned. They sat around patiently in a circle on the ground until the distribution began, and at last they went away loaded. A tall black who was 'straight as a candle' provoked great amusement, and we christened him straight away 'Soldier'. He was the last to march off. On his head he carried the cow's skull, and down over his back hung the hide with feet and tail. 'Soldier' now looked even more warrior-like than ever, similar to one of those wild Nordic fighters who decorated their heads in a like manner when the horn decoration was an adornment and an honour to a man.

In return, our black table companions brought us a variety of things: fish, rats, lizards and roots. Not particularly dainty morsels according to European standards, but quite acceptable as a change from the eternal beef menu. Lacking tea, we sampled a type of peppermint that grew along the creek and also tried Nardu seeds as coffee. Both attempts failed, as did the attempt by the smoking members of the party to substitute eucalyptus leaves for tobacco. The imagination of these 'matter of fact' humans was not strong enough to help them overcome the tasteless reality.

I had enough leisure and opportunity to closely observe my new friends. With time they became quite friendly, trusting and forward. As the shyness disappeared through daily contact it was necessary for us to ward them off. Everything which we threw away was, as a rule, taken away by one or the other. Glass and broken glass pieces were much sought after articles. Used to smooth and to point weapons, these were better instruments than the rare quartz pieces that previously served the purpose. Other things would be happily taken away but soon discarded. Clothing had no attraction for these 'nature people', all of whom existed here, in summer and winter, as did our ancestors in paradise. The absence of clothing of every type is explained by the inadequacy of the animal world, which could only provide a few hides. Furthermore, the days are so warm that even in winter, the rainless time, they can get by without protection. The only real clothing or body covering was an apron made from tassels of animal fur worn by the more distinguished men and small handsize aprons made from tightly woven net which some of the women put on at times. The aprons of the men certainly served only to decorate, and were only worn at ceremonies and in fights. They were very precious, requiring much work and effort, and were an heirloom passed on from father to son. Before they were finished, many animals had to be hunted. An 'Unpa' made from tassels of 'Wallaby' fur (Halmaturus), was not as valuable by far, as a 'Thippa' made from over 300 tails of the Belideus (bandicoot), which, in a clean condition, (unfortunately, rarely) looked very beautiful in its snow-white colour. The man who could wear such decorations at the great ceremonies for which the tribes came together or when the warriors went out to fight was indeed a mighty hunter or warrior. Just as highly regarded, perhaps more so, was the string spun from human hair. This was up to 200m. long and rarely seen. Many a human head provided its hair, and the

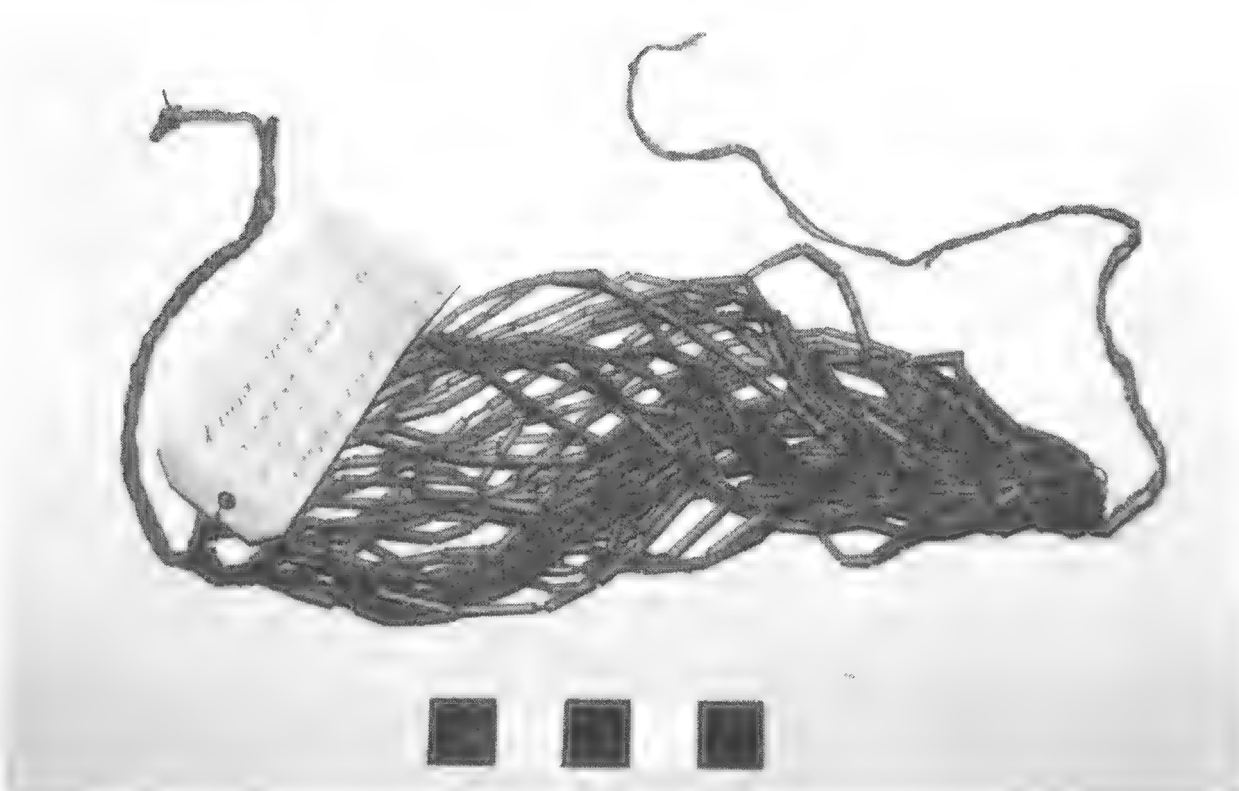

FIGURE 3. Example of a *Cultaculta*, a necklace made of grass stems. Collector unknown, Cooper's Creek. Unregistered, South Australian Museum.

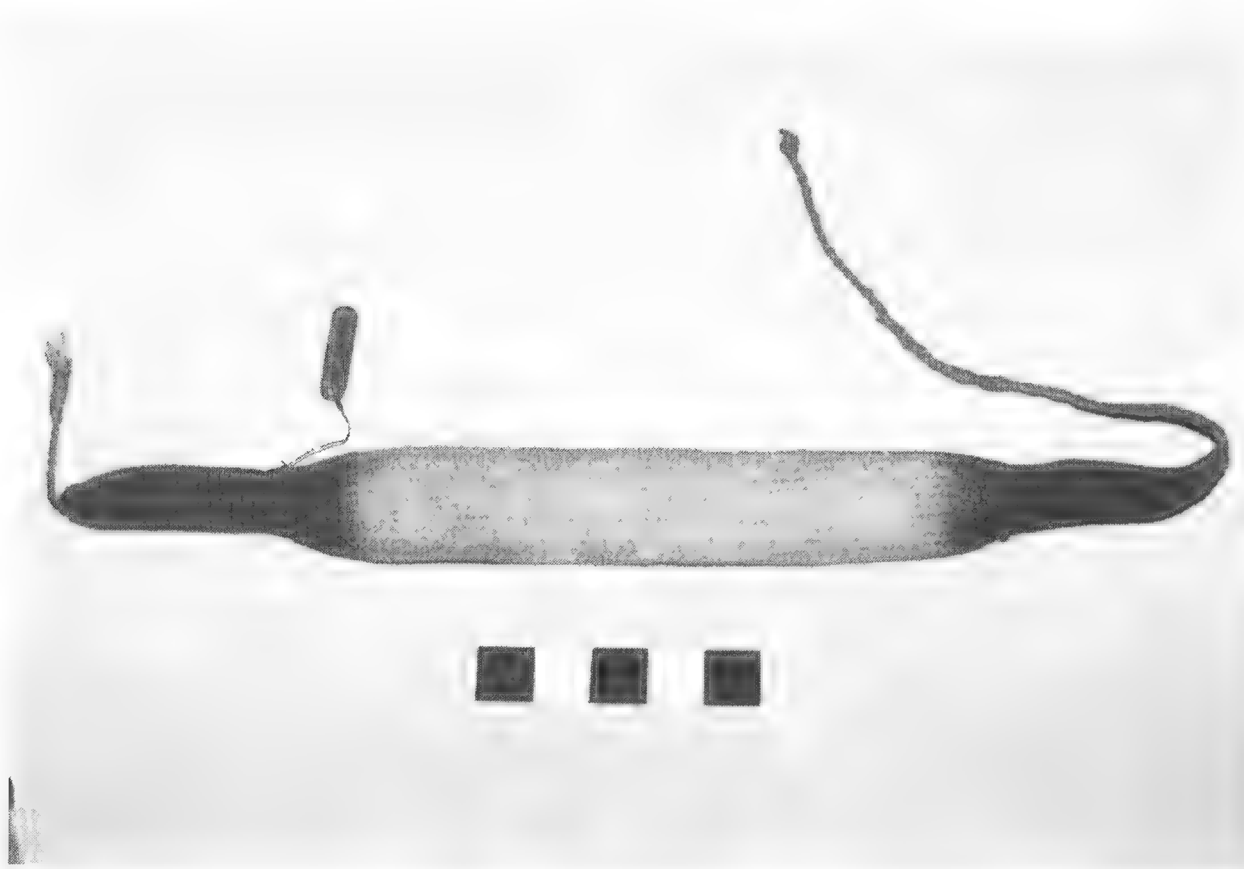

FIGURE 4. Headband made from plant fibres. Collected by J.G. Reuther, Kopperamanna. A3016, South Australian Museum.

hair of the dead is also spun into the 'Yinka' so that it receives a special power. The abilities or skills of those living and the dead who gave their 'head hair', are bound into the girdle and pass into those who wear it, giving them increased power. From the girdle hung the 'Wurtawurta', a bundle made from black emu feathers.

The Aborigines' shaggy hair was held together by the white coloured 'Tschangu', a headband made from plant fibres. The arm was decorated with an 'Unamunda', a string made from the same materials and wound many times around the arm. The old people of importance and influence put on the 'Wurdawurda', the wreath made from emu feathers which they alone deserved. A shell also hung from a band of human hair around the neck or decorated the tips of a not very long yet highly valued beard.

The inhabitants of the Cooper differ from their neighbours in the West, who keep the sides of their faces free from hair by pulling or tearing it out. They also differ from the Northern tribes who remove all facial hair. They allow all that will grow to grow: the full beard for them is a decoration. The head hair is also not touched, however, like the beard, it does not grow very long. In certain ceremonies the hair is shorn very short as a sign of mourning, but as a rule only the women had to undergo the 'tonsure' (the hair clipping). Women have their decorations but, as the role of the women is lower than that of the man, it is considered appropriate that the decoration is less precious and less attractive. The 'Mundamunda', the women's girdle, is spun only out of plant fibres, and the 'Kultrakultra' is made only from pieces of reed which are strung on a string. The women played the same sad role as a slave as everywhere in Australia. They had to put up with every treatment from their tyrant, who in every way had the women at his disposal. They could be killed without any punishment. However, cases also existed in which the relationship was reversed and the master became the obedient servant, and it was the same everywhere in Australia where nobody would help the husband against his shrew.

During a stay of many months I was easily able to study the manners, customs, character and the language of these people. The study was much more interesting than my earlier observations of tribes who had already been, for a longer or shorter time, in contact with the white man and so had lost some of their true and original nature. However, at Coopers Creek it was still a virgin soil on which I stepped well prepared and from which I made a rich harvest.

Understanding them was not hard. The people could understand fairly well the dialect of the Paroo and the Warrego. We were often aided through drawings which they made very skilfully in the sand and soon learnt to make on paper. The flows and breadths of the rivers and creeks, the relative heights of the hills; the distances of fixed points, and the relationship between those points they described with a precision that never let me down during my extensive excursions to the north and north-west. The route of Burke and Wills, which I followed a long way in the direction of the Gulf, I received partly from them, and partly from the envoy of the Munamuckaru tribe of the Daly River who was coincidently present. Their descriptions of the different camping places of Burke as well as McKinlay were exactly correct, and they also characterised the persons by unmistakable mimicry. They were remarkably like children. They liked to look at a thing that was new to them and wanted to touch and possess it. Then, after the attraction of the novelty had worn off, it was thrown away or exchanged for something else. They were easily directed with friendliness and consistency. Alternately, they were easily offended then easily reconciled, soon won over by promises then badly hurt by their being broken, pitying and generous, then quickly vengeful and cruel. So long as they saw us as superior beings whose power was real and to be feared we could meet together with one another. We were never attacked by them due to our vigilance and their fear of our guns (fire weapons), despite them being a hundred fold superior in number. It was probably also due to the beneficial impression and satisfaction they had received in earlier times from the contact with the expeditions of the white man.

We soon found the opportunity to make a wider acquaintance with the whole population of the extensive Cooper district. One day, while still a great drought prevailed, hundreds of visitors arrived from the north and the north-west. They often used this same ceremonial place to call the rain down from heaven and were invited by our neighbours who were the actual rulers of this hunting ground. Women in the company of their 'Pirraru', their 'cavalieri serventi', were sent out to gather the scattered people. We had the opportunity to observe the whole event; the people had no inhibitions about the presence of the strangers or even the white people at this ceremony. The men distanced themselves approximately 500–600 metres from the camp to find an empty site, and dug a depression four metres long, three metres wide and approximately one metre deep. Others dragged heavy wooden logs to build a cone-shaped hut covered by small branches and grass with a low, narrow entrance. Two large stones from the nearby creek were placed in the middle of the hut. The old men took their places inside, while the younger men sat down outside. One of the youngest went to the camp to fetch the women. They came and without speaking a word, looked at the structure, looked inside the hut and then removed themselves. As soon as the women had returned to the camp, the elders called two young, strong people outside and bound the veins of their upper arms. One of the oldest, perhaps the most significant and influ-

ential of them, took a sharp stone and opened the veins. The blood spurted onto the densely gathered group. Those who were bleeding threw handfuls of down feathers from already prepared nets over the others. The feathers stuck onto the wet bodies. The women reappeared to look at the men who now were covered with blood and feathers. The two youths who had been operated on then took the two stones, carried them miles away and hid them in the highest branches of a tree. Those staying behind collected slices of the so-called 'women's ice' that lay in great quantities on the distant mountain range, pounded it, then scattered the powder into the waterholes. One thing remained to be done: the destruction of the hut. The whole group of men stood around in a circle and, with lowered heads, ran towards the hut, smashed the dry branches and appeared on the other side. They then returned to the attack until nothing remained except the heavy wooden logs. These they grasped at one end and pulled them back until the hut collapsed in an unformed heap. Then it was back to the camp to dance. On that night of the full moon, the dancing lasted until the early morning. For the whole night the ground resounded from the heavy stamping of the dancers, and the air reverberated from the monotonous noise of the rhythm which the women beat on their carrying dishes.

A young, intelligent Aboriginal, who had already gone through all stages of initiation, (including the last, most painful and most peculiar rite that was found only in this region), explained that the blood sprayed around signified the rain, the feather down signified the light clouds and the stones signified the heavy pregnant rain clouds. The destruction of the hut symbolised the breaking down and flow from the clouds, and the fall of the hut represented the fall of the rain. That's how I understood him. The good spirit 'Muramura' saw these ceremonies, collected the clouds and the rain poured down. But also perhaps not. The explanation is the same as with all other ceremonies, entreaties or conjuring exercises that failed to achieve an aim or produce a result: an enemy or hostile tribe had spoiled the magic through a contrary incantation. It almost appeared as though the latter was the case. Many weeks passed since that ceremony. The blacks had long since scattered. Our stocks were almost totally consumed, and our isolation became complete when we lost our closest neighbour on the Wilson. Only when Swanhill Jack, my best and most fearless stockman, risked, at increasingly distant intervals, the lonely and distant journey to the next station on the Bulloo, did news of the outside world reach us. Even there one was already almost totally isolated. Old newspapers were now devoured with eagerness, and a new book would have been worth a good cow.

'The longest lane has a turning', says an English proverb meaning that nothing lasts forever. At some time things must change, and so things did change with us on the Cooper. At last the rain came and in the torrents as is usual in Australia. We retired a reasonable distance away to the sandhills or plateau behind us. Soon everything around us was transformed into a surging expanse of water. We were on one island with our horses, cut off from our herd which was scattered in groups here and there, grazing on similar islands. The "blackfellows" had dispersed. The water soon subsided again, but we remained stranded on our island as the black, soggy flats were impassable and the treacherous beds of many small creeks restricted us on all sides. Now we were about to get to know our wild brothers from a different perspective. From the high elevation of our sandhills, we had a panoramic view which included the river flats on both sides. One day we could see that a large hunt was starting on our cattle, who could only move with difficulty in the muddy ground. The greedy hunters sought out the largest animal, and an old well-fed steer fell under their clubs and spears. Soon, however, they had better sense and chose younger animals. Not only did they kill the cattle, but they also cut out the knee joints and sinews, and speared them. They were determined to destroy them by all means. We had to watch this hustle and bustle from a distance. They were no longer scared of the crack of our guns which they saw could not reach them, and answered every shot with scornful shouting. To our consolation they were sometimes introduced to the character of these animals in a most perceptible way when they came too close to the tormented cattle. At last came the day when we could rise up as revengers of the fallen. The earth was dry enough to carry us and our horses.

We prepared ourselves with rifles and revolvers for what would certainly be a hard fight. Although we rode cautiously, our coming was betrayed in advance. As we neared the camp of the blacks, it was a case of 'sauve qui peut' or 'everyone for themselves'. The men, who were totally unconcerned about the women and children, ran in great haste over the flat to the creek, threw themselves into it, swam across and disappeared behind the sandhills lying there. The women, loaded up with children and all kinds of possessions, were soon rounded up. I believe the poor creatures thought their last hour had come. I had as little reason to vouch for the security of the men had we caught them as I had to believe that one of my people would raise a hand against a woman. We indicated to them to turn back. Trembling and quietly lamenting, they marched back to camp. There I ordered them to pull together a heap of brushwood and to lay all their belongings (which were not many) on top of it. A few weapons which, in the haste, were left behind, I kept for myself. The remaining things – carrying dishes; greasy nets; girdles; skin aprons and coats; and, 'last but not least', the small knitted net bags with magic bones and red ochre were all put on

the pyre. Without hesitation or resistance the people obeyed my commands, then stood silently around. The flames snaked upwards and reached their miserable possessions. Then, as if they thought that the burning of these magic instruments must bring about the death of relations, spouses, and children, there rose a wailing and moaning that certainly reached their menfolk – their 'protectors' – who were secure some distance away. They probably thought that their wives and offspring whom they had so cowardly abandoned were being killed by our guns and knives. But the eyes of our blacks were fixed with concentrated attention on the glowing mass. Before we knew what was happening, eager hands, careless of burns, reached into the fire in order to save the amulets from the fiery oven. What were these pains and wounding compared to the certain death which was being prepared for them and others? Nevertheless, justice had to be done, and I stayed until those amulets were turned to ashes. Then we turned our horses and left the place. I was curious and also worried about what would follow that 'auto da fe' (punishment by burning) for the inhabitants. Although I made many enquiries, I could never determine whether any person had sometime later suffered a misfortune in connection with that event. I can well say that I was relieved over that. In retrospect, I could see that the behaviour of the Aborigines was justified. What they had done was based on their concept of what they must do as their right and duty. They wanted to show the foreign intruders who wished to use their hunting ground for grazing ground that his cattle could not live where their hunting animals must live and where they themselves should live. They used legitimate means. They submitted themselves as long as they had to, then made use of the favourable opportunities as they came. What could be more right and understandable?

A few weeks later I turned my back on the Cooper, the bush and the wilderness forever, and drove my herd down the Strzelecki. The floods had not arrived there. There was scarce water at only a few places. The worst that happened was when we crossed salt lakes on the downward run. These lakes were tempting for the thirsty animals but dangerous. I had solved by that expedition an important problem for the settlement of Australia, and proved that even in drought years it is possible to transport cattle over long distances of desert and pastureless tracks to the capital city of South Australia. This changed the squatters' thinking on pasture and acquisition, enabling practices which have already for some years become a profitable reality.

Acknowledgments

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A NEW GENUS OF MARSUPIATE SPATANGOID ECHINOID FROM THE MIOCENE OF SOUTH AUSTRALIA

K. J. McNamara & D. J. Barrie

Summary

The southern Australian Tertiary fossil record contains a relatively rich fauna of marsupiate echinoids. The 10 species currently known are placed in five genera, and are supplemented by this description of a new genus and species of marsupiate spatangoid echinoid, Hysteraster paragrapsimus gen. et sp. nov. Collected from the late Early Miocene to early Middle Miocene Morgan Limestone on the banks of the Murray River, South Australia, this new form is characterised by the possession in the female of deeply sunken apical system and petals on the aboral surface. The male of this genus can be distinguished from the female by its much smaller gonopores and lack of sunken petals. The genus is placed in the family Brissidae and, as such, is the first record of a marsupiate genus in this family.

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The southern Australian Tertiary fossil record contains a relatively rich fauna of marsupiate echinoids. The 10 species currently known are placed in five genera, and are supplemented by this description of a new genus and species of marsupiate spatangoid echinoid, *Hysteraster paragrapsimus* gen. et sp. nov. Collected from the late Early Miocene to early Middle Miocene Morgan Limestone on the banks of the Murray River, South Australia, this new form is characterised by the possession in the female of deeply sunken apical system and petals on the aboral surface. The male of this genus can be distinguished from the female by its much smaller gonopores and lack of sunken petals. The genus is placed in the family Brissidae and, as such, is the first record of a marsupiate genus in this family.

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The Tertiary rocks of southern Australia contain one of the richest echinoid faunas of this age in the world, with some 60 genera having been described (McNamara in prep.). A characteristic feature of this fauna is the presence of marsupiate echinoids - those echinoids that bear depressions in their test that were used for brooding the young. To date some 10 marsupiate species have been described from the Tertiary rocks of southern Australia, all by Philip & Foster (1971). At the time of their publication only one other Tertiary marsupiate echinoid was known from elsewhere in the world: *Abatus pseudoviviparus* (Lambert), from the Paleocene of Madagascar. However, since then Roman (1983) has described a further four species from the Middle Miocene and Pliocene of western Europe. Of this total of 15 Tertiary species, only three are spatangoids: *Abatus pseudoviviparus*, and the two species of *Peraspatangus* that Philip & Foster (1971) described from Australia, *P. brevis*, from the Early Miocene, and *P. depressus* from the Middle Miocene.

The discovery of two specimens by one of us (J. B.) of a hitherto undescribed spatangoid genus from the late Early to early Middle Miocene Morgan Limestone downstream of Waikerie on the banks of the Murray River, therefore brings to three the number of marsupiate genera of spatangoid echinoids now known from the Tertiary. A single specimen in the collections of the Museum of Victoria is also referred to this genus, as is a specimen from Wigley Reach, near Overland Corner on the Murray River in the collections of the South Australian Museum. Although lacking the sunken petals and apical system characteristic of the females, the other test characters appear to be sufficiently similar to indicate that this lone specimen is the male of the species.

Stratigraphy

The Morgan Limestone, from which the type specimens were collected, outcrops along the bank of the Murray River in the vicinity of Morgan. In its type section, six kilometres south of Morgan, the unit reaches a thickness of about 30 m (Ludbrook 1961). In some parts of the Murray Basin it is up to 100 m thick (Ludbrook 1969). The Morgan Limestone straddles the Early to Middle Miocene boundary in age (Australian stages Batesfordian to Balcombian, Lindsay 1985). The dominant echinoid is a clypeasteroid, *Monostychia* sp. Other echinoids collected from this unit include *Phyllacanthus clarkii* (Chapman & Cudmore) (Philip 1963); *Goniocidaris murrayensis* Chapman & Cudmore (Philip 1964); *G.*? *pentaspinosa* Chapman & Cudmore (Philip 1964); *Delocidaris prunispinosa* (Chapman & Cudmore) (Philip 1964); *Menocidaris compta* Philip 1964; *Murravechinus paucituberculatus* (Gregory) (Philip 1965); *Cryptechinus humilior* (Bittner) (Philip 1969); *Ortholophus morganensis* Philip 1969; *O. pulchellus* (Bittner) (Philip 1969); *Schizaster (Schizaster) abductus* Tate (McNamara & Philip 1980); *Pericosmus compressus* (Duncan) (McNamara & Philip 1984); *Protenaster antiaustralis* (Tate) (McNamara 1985); *Cyclaster archeri* (Tenison Woods) (McNamara *et al.* 1986); *Eupatagus rotundus* Duncan (Kruse & Philip 1985); and *E. ludbrookae* Kruse & Philip 1985.

Material and Methods

The material described in this paper is deposited in the collections of the South Australian Musuem (SAM) and the Museum of Victoria (MV). Measurements

were carried out using electronic callipers to a precision of ±0.1 mm. Relative sizes of features of the test are expressed as percentages of maximum test length (%TL).

Systematic Palaeontology

Order Spatangoida Claus, 1876

Family BRISSIDAE Gray, 1855

Genus *Hysteraster* gen. nov.

Etymology

From the Greek *hystera*, meaning 'womb', and *aster*, meaning "star", alluding to the formation of the marsupium from the star-shaped petals.

Diagnosis

Test moderately large, relatively narrow and with slight anterior notch. Apical system set well anterior of centre; deeply depressed in females. Petals short, broad and deeply depressed in females, only slightly depressed in males; do not extend to peripetalous fasciole; pore pairs very reduced in size in anterior rows of anterior petals; in all petals pore pairs absent in vicinity of apical system. Apical system ethmolytic with four gonopores. Peripetalous and subanal fascioles present. Aboral tubercles much larger within peripetalous fasciole than outside of it; those in interambulacra 2b and 3a are the largest and most sparsely distributed. Peristome subcentral. Plastron small, with prominent posterior keel. Periplastronal area wide.

Remarks

There seems little doubt that the deeply sunken petals in *Hysteraster*, combined with a deeply sunken apical system, functioned as a marsupium. This is supported by the presence of large gonopores in the female (see below). *Hysteraster* can be distinguished from all other marsupiate spatangoids by its possession in the female of both deeply sunken apical system and deeply sunken petals. In the living spatangoids *Abatus* and *Tripylus*, which also have deeply sunken petals, the apical system is not depressed at all. The only spatangoid to share the combination of sunken aboral ambulacra and apical system is the Australian Tertiary genus *Peraspatangus*. However, in this genus just a simple depression is formed, comprising the apical system, the adapical ambulacra and interambulacra, whereas in *Hysteraster* the adapical interambulacra are not sunken. Unlike *Peraspatangus*, with its non-petaloid adapical ambulacra, pore pairs are present in the marsupium in *Hysteraster*, although they do degenerate in the vicinity of the apical system and in the anterior rows of the anterior petals.

One of the specimens, SAM P24260 (Fig. 2) shows the presence of a well developed subanal fasciole. Consequently it is possible to place *Hysteraster* within the Brissidae with confidence as a peripetalous fasciole is also present. Furthermore, the overall appearence of the test, the presence of a prominent plastronal keel, a feature usually present in those genera possessing a subanal fasciole, and the development of larger tubercles within the peripetalous fasciole, support the emplacement of *Hysteraster* within the Brissidae. This is the first record of a marsupiate genus within this family. Although a few other brissid genera, such as *Rhynobrissus*, *Macropneustes*, *Meoma* and *Schizobrissus* have sunken petals, they are much shallower than in *Hysteraster*, and there is no evidence that such forms were marsupiate.

The male *Hysteraster* can be distinguished from other brissids by the nature of its relatively short, broad, slightly sunken petals; its very anteriorly situated apical system; degenerate pore pairs in the anterior row of the anterior petals and distinctive aboral tuberculation. The only other genera that possess some of these characters are *Migliorina* and *Plesiopatagus*. However, *Hysteraster* differs from the former in possessing larger tubercles inside the peripetalous fasciole, and from the latter in its possession of four, rather than two, gonopores. Furthermore, neither of these two genera is known to be marsupiate.

One of the characteristic features of *Hysteraster* is the failure of the anterior paired petals to reach the peripetalous fasciole (Fig. 4). There are few other spatangoids which share this attribute, but one is the living marsupiate *Tripylus*. However, in the other living marsupiate spatangoid, *Abatus*, the anterior petals do reach the fasciole. An unusual feature of *Hysteraster* is the presence of the enlarged primary tubercles, not only on the interambulacra within the peripetalous fasciole, but also in ambulacra II and IV between the ends of the petals and the fasciole. Selective pressure for the presence of primary tubercles must have been particularly strong.

Hysteraster paragrapsimus sp. nov.
(Figs 1–4)

Etymology

From the Greek '*paragrapsimos*', meaning 'exceptional', in reference to the extent of development of the marsupium.

Material

Holotype: SAM P32322, from the late Early to early Middle Miocene Morgan Limestone, Murray River cliffs, downstream from Waikerie at Broken Cliffs, South Australia.

Paratypes: SAM P32323 from the same horizon and locality as the holotype; SAM P24260, probably

FIGURE 1. *Hysteraster paragrapsimus* gen. et sp. nov. SAM P32322, holotype, ♀, from near Waikerie at Broken Cliffs, Murray River, South Australia; Morgan Limestone; A and B stereopair of aboral surface; C, adoral surface; D, lateral view; all x1.3.

from the same horizon at Wigley Reach, near Overland Corner, Murray River cliffs; and MV 18039, probably from the Morgan Limestone near Morgan, South Australia. Mr F. Holmes (pers. comm.) informs us that no locality details are entered for this specimen in the catalogues of the Museum of Victoria. However, it is registered with a suite of specimens that was collected by F. A. Cudmore form the Morgan Limestone in the vicinity of Morgan.

Diagnosis

As for the genus.

Description

Test moderately large, reaching up to 54 mm TL in females; male has test length of 30.5 mm; ovate, with a very faint, broad anterior notch in some specimens and broadly rounded ambitus; highest posteriorly in interambulacrum 5, midway between apical system and posterior ambitus; height 50–55%TL in females, 55%TL in male; test longer than wide, width ranging between 84–88%TL in females and 83%TL in male; widest posterior of centre. Aboral surface plunges steeply anteriorly (Figs 1D, 2E). Apical system anteriorly eccentric, 27–30%TL from anterior

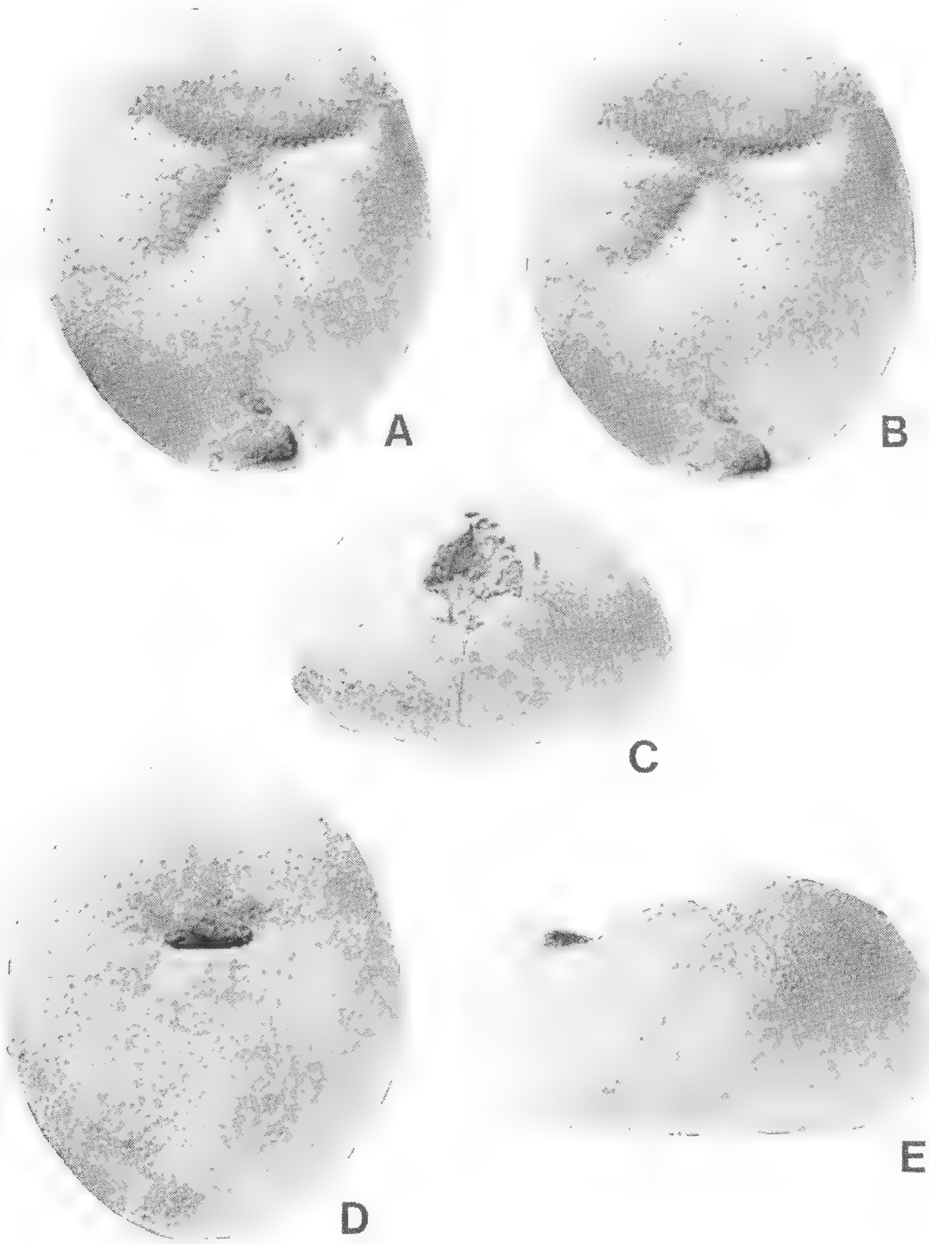

FIGURE 2. *Hysteraster paragrapsimus* gen. et sp. nov. SAM P24260, paratype, ♀, from Wigley Reach, near Overland Corner, Murray River, South Australia; Morgan Formation; A and B, stereopair of aboral surface; C, posterior view; D, adoral surface; E, lateral view; all x1.3.

ambitus in females, 32%TL in male and extremely deeply sunken in marsupium in females, up to 56%TH from apex of test in paratype female; only slightly sunken in male; ethmolytic, with four gonopores; very large in females (Fig. 1A,B); very small in male, one-seventh the female width; anterior pair in female circular, in holotype 1.3%TL in diameter; posterior pair pear-shaped, long axis 2%TL; madreporite extends slightly beyond posterior gonopores (Fig. 4).

Ambulacrum III narrow and not sunken close to apical system, becomes a little wider and very slightly sunken as crosses anterior ambitus; pore pairs extremely small; number not known. Petals relatively short, broad, although narrowing distally, and open distally; distal one-third not sunken; proximal two-thirds deeply sunken in females, plunging to deeply sunken apical system (Figs 1A,B; 2A,B; 3A,B; 5); slightly sunken in male (Fig. 3G). Anterior petals straight, broad, width 8–9%TL; diverge anteriorly at about 150°; short, 18–19%TL; bear up to 12 pore pairs within petals, those in ambulacra IIb and IVa very reduced in size (Fig. 4), about one-third size of those in IIa and IVb; pore pairs degenerate at about one-quarter petal length from apical system in poste-

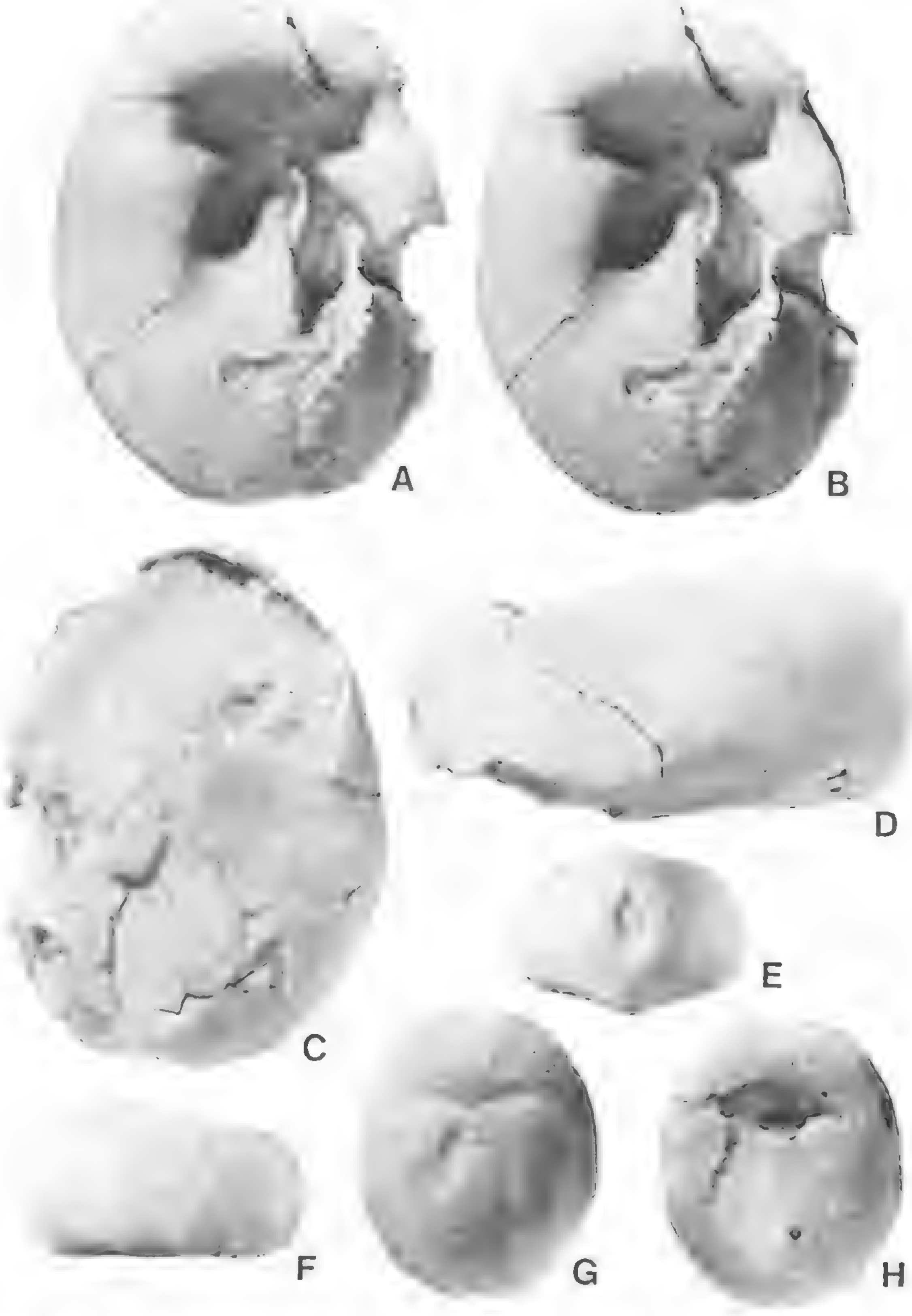

FIGURE 3. *Hysteraster paragrapsimus* gen. et sp. nov. A-D, SAM P32323, paratype, , from near Waikerie at Broken Cliffs, Murray River, South Australia; Morgan Limestone; A and B, stereopair of aboral surface; C, adoral surface; D, lateral view. E-H, MV P18039, paratype, , probably from the Morgan Limestone near Morgan, South Australia; E, posterior view; F, lateral view; G, aboral surface; H, adoral surface; all x1.3.

rior row; pores slightly elongate proximally, becoming circular distally, not conjugate. Posterior petals longer than anterior, being 31–35%TL; bear up to 17 pore pairs; pores in each poriferous tract of similar size; reduced adapically; slightly broader than anterior petals, being 10–11%TL; petals diverge posteriorly at about 50°.

Peripetalous fasciole quite narrow, about 1.5%TL in width; not indented between anterior and posterior petals; runs along the ambitus anteriorly, and close to the ambitus opposite anterior petals; both anterior and posterior petals fail to reach the fasciole (Fig. 4). Subanal fasciole subtends a chevron shape outline (Fig. 2C) that is 35%TL in width; fasciole twice width of peripetalous fasciole.

Aboral tubercles very variable in size; outside of the peripetalous fasciole towards the ambitus very densely distributed and small, up to a diameter of 0.3 mm; within the peripetalous fasciole in interambulacra 1, 4, 2a, 3b and 5 tubercles larger and more sparsely distributed, up to a diameter of 0.9 mm; these are also present in ambulacra II and IV between ends of petals and peripetalous fasciole; in interambulacra 2b and 3a they are larger still adapically (Fig. 1A,B) and even more sparsely distributed, with up to eight crenulate tubercles that reach 1.25 mm in diameter.

Adoral surface gently convex. Peristome slightly sunken; width 15–18%TL; anterior situated 28–32%TL from anterior ambitus (Fig. 2D). Phyllode comprises 6 small unipores in ambulacra I, II, IV and V; 3 in ambulacrum III. Labrum short, 5%TL; not projecting anteriorly across peristome. Plastron narrow, length 40%TL; width 25–28%TL; almost flat, but forming a prominent keel posteriorly (Fig. 3E). Periplastronal area wide (Figs 1C; 2D; 3C,H), up to 17%TL. Periproct oval, long axis vertical (Fig. 3E), 15%TL. Adoral tuberculation relatively sparse, but becoming more dense adambitally; tubercles up to 0.8 mm in diameter.

Discussion

Most of the slight differences that are observed between the three female specimens and the sole male probably relate to the size difference between the females and the male, the latter being only slightly more than half the size of the former. These differences include relative test height, test width and position of the apical system. Whether or not the size difference itself is a sexually dimorphic feature is not clear. While a greater range of specimens would be required before this could be ascertained, Kier (1969) and Smith (1984) have noted that female echinoids are often larger than males.

In addition to the obvious reflection of the sexual dimorphism, namely the presence of the marsupium of the female and its absence in the male, the difference in gonopore size between the females and the male is another sexually dimorphic feature. Such dimorphism has been documented in some echinoid species by a number of authors, *e.g.*, in *Pentedium* by Kier (1967), in *Echinocyamus* and *Oligopygus* by Kier (1969), in *Echinocardium* by David *et al.* (1988) and in *Hemiaster* by Jagt & Michels (1990); see also Emlet (1989). However, whereas the difference in gonopore diameter in these non-marsupiate forms never differs by more than a factor of two, in *Hysteraster*, and in the other Australian Tertiary marsupiate spatangoid *Peraspatangus*, it is much greater, presumably to accomodate the larger eggs produced by these brooding species.

Wray & Raff (1991) have noted how echinoids that produce the largest eggs are brooding species, egg size ranging between 1 and 2 mm in diameter. Emlet (1989) has observed that marsupiate echinoids in general have particularly large gonopores, relative to their body size, presumably to accommodate the large eggs. The gonopores of female *H. paragrapsimus* reach up to 1.2 mm in diameter. In *Peraspatangus brevis* Philip & Foster, 1971 the female gonopores are nearly four times the diameter of the male gonopores (Philip & Foster 1971, pl.133, fig. 4). In *Hysteraster paragrapsimus* it is even greater, the gonopores in the larger female (Fig. 1A,B) being about seven times the diameter of those of the male. However, this is in part a function of the differences in test size between the male and female forms. Emlet (1989) has noted that there is a positive relationship between increasing test size and increasing gonopore size. For instance he has shown how in males of the living marsupiate echinoid *Amphineustes lorioli* there is an approximate doubling in size of the gonopores as the test length doubles. In females the allometric coefficient is even greater (see Emlet 1989, figure 3). In *Hysteraster paragrapsimus* the extent of increase in females is likely to be as great.

Although *Hysteraster paragrapsimus* and the two species of *Peraspatangus* are the only spatangoids that possess a marsupium that is constructed from a combination of sunken petals *and* apical system, there is one feature in which the two genera differ from one another. In *Peraspatangus* the ambulacra in the marsupium do not possess any pore pairs. While they are present in the marsupium in *Hysteraster* they are very much reduced in the vicinity of the apical system and in the anterior rows of the anterior petals (see Fig. 4).

There is some difference in the degree of development of the marsupium in the female specimens of *Hysteraster paragrapsimus*. In the paratype SAM P32323 the marsupium attains a depth that is nearly twice that of the marsupium of the holotype. However, as the two specimens are virtually identical in all other respects, it is considered that this difference merely reflects intraspecific variation. The smaller female specimen (SAM P24260) has a marsupium

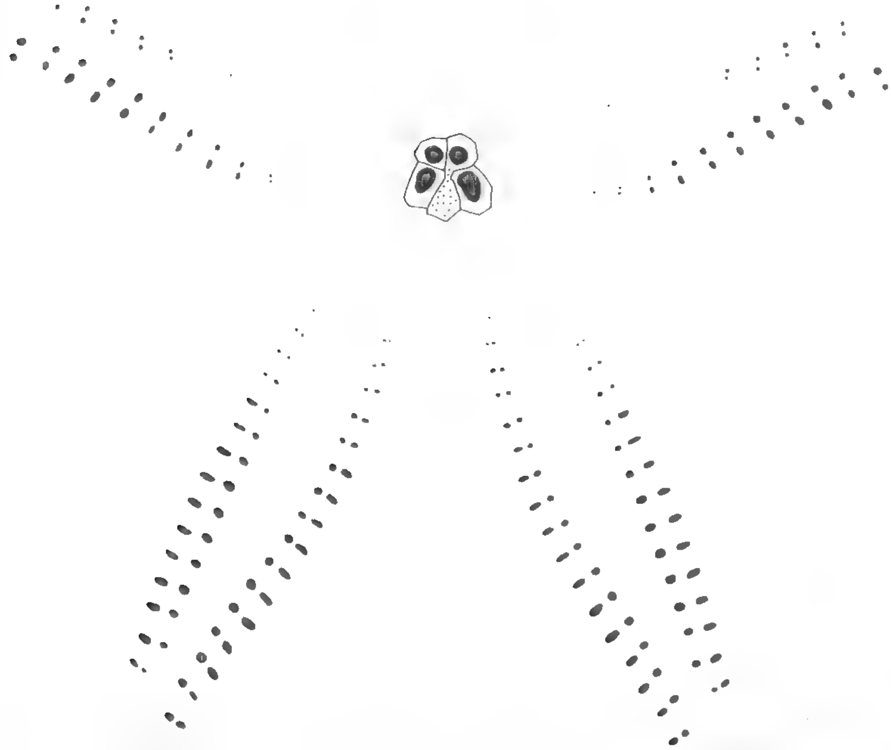

FIGURE 4. Drawing of pore pairs in petals of *Hysteraster paragrapsimus* gen. et sp. nov., holotype, ♀, SAM P32322. Note reduction in size of pore pairs adapically; large gonopores; and failure of pore pairs to reach the peripetalous fasciole.

that is similar in depth to that of the holotype, but the adapical interambulacra surrounding the marsupium are more swollen in this smaller specimen, so enhancing the effective depth of the marsupium.

Functional morphology of *Hysteraster*

Certain characteristics of the test indicate that *Hysteraster* shares the distinction, along with the living spatangoids *Abatus* and *Tripylus*, of being the only echinoderms known to brood their young while buried in the sediment. The existence of a well developed peripetalous fasciole, combined with the wedged shape profile of the test indicate that *Hysteraster* lived completely buried in the sediment. Peripetalous fascioles are a prerequisite for spatangoids that completely burrow in the sediment, while McKinney (1988) has observed that a wedged shape test is often found in spatangoids that burrow in relatively fine-grained sediments, such as those in which *Hysteraster* are preserved. Other brissids that, like *Hysteraster*, possess larger primary spines on the aboral surface are interpreted as being shallow burrowers, with their aboral surface just covered by sediment (McNamara 1991). Further evidence that these genera brooded their young while buried in the sediment is afforded by the preservation of tiny juveniles in the petals of two specimens of the Paleocene species *Abatus pseudoviviparus* (see Lambert 1933, pl. 4, figs 5–7). Such preservation could only occur if there was no disturbance to the specimen after its death, such as would have been the situation with a specimen completely buried by sediment – it was 'preadapted' to being fossilised.

In the case of these burrowing marsupiate spatangoids, following their 'birth' the young echinoids would have nestled in the deep marsupium on the aboral surface of the test (Fig. 5). This method of brooding could have provided the young with exceptional protection from predators for a number of reasons. In addition to the presence of the deep marsupium, the tent of mucus that the peripetalous fasciole would have throw over the marsupium would also have protected the young echinoids. Furthermore, the larger spines that arched over the petals from interambulacra 2 and 3 would have provided a protective advantage. Orientation of the prominently

crenulate tubercles provides evidence that the spines would not have extended perpendicular to the test, but at a very low angle, almost tangential, to the surface of the test across the petals. Finally, the young echinoids would also have been protected from predators by the sediment that would have covered the entire aboral surface of the test.

The absence of pore pairs in the vicinity of the apical system in *Hysteraster paragrapsimus* and reduction in size of the pore pairs in the anterior row of the anterior petals, combined with the absence of pore pairs in the marsupium in the two species of *Peraspatangus*, suggest that their reduction may be related to the presence of brooded juveniles in the marsupium. Brooding in ambulacral marsupia can only be effective if tube feet are reduced in size to allow sufficient space in the petals to accomodate the juveniles. If this is the case then it is likely that the brooded juveniles were concentrated in the area immediately surrounding the apical system, along the anterior part of the anterior petals, and perhaps in the central part of the posterior petals, between the pore pairs. It is worth considering whether the presence of reduced pore pairs in the anterior row of the anterior paired petals in other spatangoids, such as *Atelospatangus, Paramaretia, Nacospatangus* and *Agassizia,* is indicative of these echinoids also being brooders.

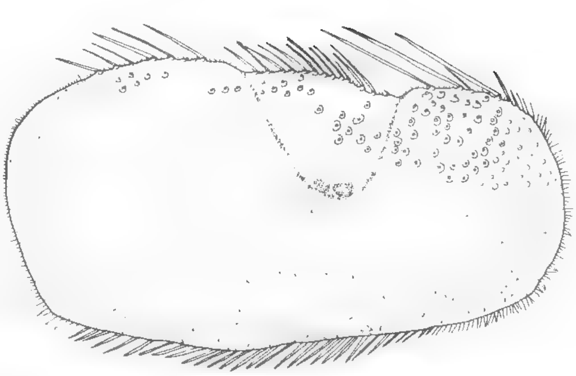

FIGURE 5. Restored profile of *Hysteraster paragrapsimus* gen. et sp. nov. ♀, showing course of peripetalous fasciole, distribution of primary tubercles and extent of maximum known development of marsupium. Spine orientation based on data from tubercles; spine length conjectural.

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NOTES ON FRECKLED DUCK STICTONETTA NAEVOSA SHOT AT BOOL LAGOON, SOUTH AUSTRALIA, 1980

F. I. NORMAN & P. HORTON

Summary

Freckled ducks Stictonetta naevosa (n = 164) were collected at Bool Lagoon, South Australia, following the opening of the 1980 waterfowl season. Birds were generally sexed and aged, and routine body measurements taken. Wherever possible, the identity of foods, and ectoparasites and endoparasites, was established, and moult and reproductive details were obtained from subsamples. Most ducks were adult; body masses were not low and many birds had extensive fat deposits. In this sample, the birds showed no reproductive activity but maintained body weight and fat reserves, apparently by eating a range of plant and animal foods. Counts and surveys of hunters' activities suggest that Bool Lagoon is a refuge for birds which disperse from normal breeding areas in times of drought.

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The freckled duck *Stictonetta naevosa* is generally distributed in southern Australia, particularly in the south-east and south-west. In South Australia the species is relatively rare, being found primarily in the Murray Valley, Bulloo and Lake Eyre basins, but showing occasional peaks of abundance in other areas (Parker *et al.* 1985, Marchant & Higgins 1990). Indeed, much of the population in eastern Australia may originate from the Lake Eyre basin itself (Parker *et al.* 1985). At times, numbers increase dramatically on some more southern wetlands which are used as refuges rather than breeding habitat. When such concentrations coincide with the annual open season on waterfowl, in South Australia as elsewhere in south-eastern Australia, freckled duck become an illegal part of the harvest. Relatively large numbers of freckled duck have been killed during the earlier parts of some open seasons (*e.g.* in Victoria, Corrick 1980, Corrick 1982, Norman & Norris 1982; in South Australia, Reid 1980), creating concern for the population of this poorly understood species.

Bool Lagoon, South Australia, a state game reserve of 2 690 ha, has *ca* 2 400 ha of open water when full (the adjacent Hacks Lagoon Conservation Park holds some 130 ha of additional wetland). On the opening day of the 1980 waterfowl season (1 March), there were up to 5 000 freckled duck present in the area (Parker *et al.* 1985). This note provides a summary of measurements and details of reproductive activity, parasites and diet obtained from 164 freckled duck carcasses collected at Bool Lagoon on the opening day. When collections were made, *Triglochin procera* was growing through most of the open water and freckled ducks were mainly in or around a large stand of *Melaleuca halmaturorum*, itself inundated by water.

METHODS

Carcasses of freckled duck (164) were collected in and around Bool Lagoon on 1 March 1980, either from hunters directly or from the water where they had been left. The birds were dried and frozen until later examination and or preparation as study skins (132). Once thawed, sexes and 'ages' were determined for most birds using gonad examination and the presence or absence of juvenile tail feathers. Many birds (119) were weighed (to 1g), and total body length and wing span (to 1mm, carcass relaxed and extended), wing chord length (to 1mm, gently flattened), length of central tail feathers and tarsus, bill length (feathers to tip) and bill width (at nares) (all to 0.1mm) obtained. Some birds (56) were also examined for the presence of moult in primary and secondary tracts, as well as tail and body tracts generally (here moult was considered as absent, 1; slight – moderate, 2; heavy, 3); wear of primary feathers was also scored (1 – 4, following Braithwaite & Norman 1974). Gonads from a sample of the freckled ducks (92) were drawn to scale; testes lengths were determined from the scale drawings (to 0.5mm), and follicle size in ovaries classified as developed (>3 mm) or not (see Norman & Norris 1982). Oviducts were classified as straight or convoluted. Fat deposits (subcutaneous, peritoneal, anal or thoracic) were considered collectively and assigned to a category (0 = none, 4 = heavy), and the extent of skull ossification was also determined in 58 birds. Body masses, total lengths and wing spans of most birds were obtained within six months of collection, but some freckled ducks were not weighed and measured until 15 – 24 months later. This later sample was used to identify mensural changes under storage conditions.

Ectoparasites were collected from some carcasses by brushing. Food material was removed from 39 gizzards (few birds had complete food items in oesophagi), separated into recognisable taxa and submitted, preserved, for identification. Obvious endoparasites were also collected and preserved, and later identified.

In statistical comparisons below, p values of 0.05 have been accepted as significant unless otherwise indicated and variances examined for equality.

Results

General

Of the 140 freckled duck aged, 128 (91.4%) were considered adult and 12 (8.6%) immature. Of the 146 birds sexed, 93 (63.7 %) were males, a significant departure from unity ($X^2 = 10.959$, df 1, $p < 0.001$) and one more obvious in the adults examined, where 77 (68.7 %) of 112 were males ($X^2 = 15.750$, df 1, $p << 0.001$). However, only two of the 10 birds considered immature were males. Skull ossification was complete in the 58 birds examined and fat deposits (assessed in 89 birds) were usually extensive (54 birds, 60.7 %); there were no birds without fat present (Table 1). There was no significant difference in the extent of fat assessed between adult males or females (Wilcoxon rank sum test).

TABLE 1. Fat deposits in freckled duck examined from Bool Lagoon, South Australia, 1 March 1980. (1 = slight, 4 = heavy; a = includes unaged and or unsexed birds).

		Category of deposit				
		1	2	3	4	Total
Sex/age						
Male	– adult	15	2	9	23	49
	– immature					0
Female	– adult	9	2	3	8	22
	– immature			2	3	5
All birds[a]		31	4	16	38	89

Measurements and body mass details for adult male and female freckled duck are summarised in Table 2, as are data from all birds examined. Adult male birds had significantly longer wings than adult females ($t = 6.601$, df 94, $p < 0.0001$), were longer ($t = 8.9297$, df 39.4, $p < 0.0001$) and had a greater wingspan ($t = 3.2377$, df 100, $p < 0.001$). The males were also heavier than females ($t = 9.7091$, df 93, $p = 0.0001$), had longer ($t = 9.5095$, df 92, $p < 0.0001$) and wider ($t = 4.2004$, df 94, $p = 0.0001$) bills, and longer tarsi ($t = 2.7128$, df 93, $p = 0.0080$). Tail lengths, however, were not significantly different. In neither males nor females were bill widths well correlated with bill lengths. Samples of immature males were insufficient for comparison with adults; however, immature females were shorter ($t = 2.3253$, df 22.4, $p = 0.0295$) than adults. Of the 33 adult female oviducts examined, 30 were convoluted and one slightly convoluted; seven of the eight females considered immature had straight oviducts. None of the 49 ovaries included enlarged follicles. Right testes lengths averaged 7.89 ± s.d. 1.95 mm (n = 43) and the mean left testis length was 10.18 ± 2.22 mm (n = 42). In adult males, respective lengths were 8.11 ± 1.95 (n = 33) and 10.61 ± 2.00 (n = 32) mm.

For adult males, body masses of those weighed late (mean 1 049.1 ± 57.4, n = 15), were similar to those of birds weighed nearer the time of collection (1 059.4 ± 81.7, 51), and wing spans also showed no significant difference (t-tests) between the two groups. However, mean total body length was significantly higher ($t = 3.0651$, df 66, $p = 0.0022$) in those adult males measured earlier (575.1 ± 15.6, n = 54) rather than later (561.2 ± 15.6, n = 14). In adult females, there were no such differences.

Wing wear for the 56 birds examined is summarised in Table 3. Few birds of any age or sex group had heavily worn primaries and, of the 49 adults examined, 34 (69.4 %) had wings showing slight to moderate wear. None of the ducks (58) had primary or secondary feathers in moult (absent or growing), only

TABLE 2. Measurements and body mass details (mean ± s.d., range, sample size) for freckled duck collected at Bool Lagoon, South Australia, 1 March 1980. (a = includes unaged and/or unsexed birds).

	Adult male	Adult female	All birds[a]
Body mass (g)	1057.0 (76.55; 900-1230; 66)	889.6 (79.4; 722-1064; 29)	989.9 (119.4; 570-1230; 119)
Wing length (mm)	228.3 (6.6; 209-242; 65)	219.2 (5.3; 206-232; 31)	225.9 (7.8; 206-243; 138)
Total length (mm)	572.2 (16.0; 530-610; 68)	524.3 (27.8; 420-600; 31)	552.9 (32.1; 420-610; 131)
Wingspan (mm)	803.9 (33.4; 715-866; 70)	781.8 (28.6; 730-840; 32)	793.7 (35.8; 670-866; 133)
Tarsus (mm)	44.4 (2.5; 38.0-48.0; 65)	43.0 (2.2; 37.2-46.7; 30)	43.8 (2.5; 37.0-48.9; 142)
Bill length (mm)	56.1 (2.2; 46.2-61.0; 64)	51.6 (2.0; 48.0-56.9; 30)	54.5 (3.1; 46.2-61.0; 141)
Bill width (mm)	16.3 (1.1; 11.8-17.9; 65)	15.4 (0.6; 13.9-17.2; 31)	16.2 (1.1; 11.8-20.5; 143)
Tail length (mm)	68.5 (2.5; 63.2-77.6; 50)	67.6 (2.3; 64.2-73.2; 27)	68.0 (2.4; 63.2-77.6; 103)

eight (of 58) birds had any tail moult but 55 of 60 birds examined for body tract moult showed slight to heavy amounts of replacement underway.

Foods

Food material was sorted into major taxa. Small molluscs (Planorbidae: *Glyptophysa* (= *Physastra*), *Amerianna, Segmentina, Gyraulus* and *Isidorella* spp.; Hydrobiidae: *Fluvidona* sp.; Viviparidae: *Notopala* sp.; Lymnaeidae: *Lymnaea* sp.; the sphaeriid bivalve *Sphaerium tasmanicum*), insects and larvae, ostracods (including *Candonocypris novazealandae*), amphipods and cladocerans were present in most samples, which also included *Chara* sporocarps, seeds of *Chenopodium* spp., *Sarcocornia quinqueflora* and seeds of composites, graminids and angiosperms.

Parasites

Feather lice, the amblycercan *Trinoton querquedulae* (commonly found on waterfowl) and the ischnoceran *Acidoproctus moschatae* (previously recorded only from the red-crested pochard *Netta rufina*, R. Palma, pers. comm., although *Acidoproctus* sp. has been collected from *Stictonetta* examined in Victoria, Van Mourik & Norman 1985), were found on some birds, and the trematode *Echinoparyphium* sp. in others.

Discussion

Freckled duck shot at Bool Lagoon in 1980 and examined in this study were considered to be primarily adult birds, which may have previously bred (females), although at the time of collection they had apparently regressed or undeveloped gonads (male testes were of similar size to those from freckled duck shot in Victoria, Norman & Norris 1982; in that sample the testes showed minimal reproductive activity). Most birds also showed well-developed fat deposits, and had a body mass similar (and as high) as those examined in Victoria in 1981, reflecting good physiological condition. As in that study, few ducks from Bool Lagoon had missing or growing tail feathers, primary and secondary feathers were not heavily abraded (and had, for the most part, apparently been replaced some time before the opening day, 1 March), and the incidence of body moult was extensive. Norman & Norris (1982) concluded that the Victorian sample represented birds congregating at a more permanent wetland, one used as a refuge during drought elsewhere. Freckled duck present at Bool Lagoon in March 1980 were apparently behaving in a similar fashion, concentrating outside the normal breeding range, in a semi-permanent wetland which provided drought refuge.

The freckled duck is largely sedentary but, in drier seasons, as habitat is reduced they disperse to more coastal refuge areas like Bool Lagoon (*e.g.* Frith 1982, Marchant & Higgins 1990). In Victoria, the reporting rate for this species was highest in early summer, and there were no records from May to July (Emison *et al.* 1987). In South Australia too, freckled duck tend to increase in south-eastern wetlands during summer-autumn periods (L. Best, pers. comm.). However, such dispersal is irregular in southern Australia. Bag surveys conducted between 1972 and 1979 (Braithwaite & Norman 1974, 1976, 1977, 1982; Norman *et al.* 1982) showed that few (<1%) of the ducks examined were freckled duck. However, in 1980 the proportion increased to 4.5% in Victoria (Norman & Norris 1982) and at Bool Lagoon too, numbers of freckled duck, as reflected in counts and hunter surveys, were greatest in 1980 (L. Best, pers. comm.). These irruptions apparently follow extensive inland flooding and subsequent drying periods. Parker *et al.* (1985) considered that there was a 5–9 year cycle in irruptions, related to events within the Lake Eyre basin (rather than the Lachlan–Murrumbidgee basin, *cf.* Frith 1982); a major flood occurred in the Eyre basin in 1976, and a minor one in 1977 (Marchant & Higgins 1990). From mid to late 1979, freckled duck numbers increased in south-eastern Australia and many were shot in the 1981 season (Norman & Norris 1982). Numbers at Bool Lagoon increased from September 1979 onwards, and by March 1980 there were up to 5 000 freckled duck present, of which at least 436 (and perhaps as many as *ca* 1 000) were shot (L. Best, pers. comm.; L. C. Jolley, in litt.). Despite this, some 200–300 were present between April and June but few in subsequent seasons (L. Best, pers. comm.).

In the Bool Lagoon area at least, the freckled duck, a specialist feeder (Marchant & Higgins 1990), was able to maintain body weight and fat reserves by taking a range of foods from both plant and animal sources. The species, whose status is unresolved, should be protected at such refuge wetlands.

TABLE 3. Wing wear in freckled ducks collected at Bool Lagoon, South Australia, 1 March 1980.

	Wing wear category				
	1	2	3	4	Total
Age/sex group					
Adult male	7	10	4	3	24
Immature male	1	1			2
Adult female	2	2	4	1	9
Immature female	1		1	1	3
Unaged/unsexed	2	8	7	1	18
Adults	10	20	14	5	49
Immatures	3	1	1	1	6
All birds	13	21	16	6	56

ACKNOWLEDGMENTS

Data presented here were derived from freckled duck examined, in part at least, by others. We thank the late S. A. Parker (then Curator of Birds, South Australian Museum) who initiated this study. He collected carcasses (with the assistance of South Australian National Parks and Wildlife Service staff), and organised the preparation of specimens and collection of data. We also thank L. W. Braithwaite and I. Mason, CSIRO Division of Wildlife and Ecology, for providing details of moult, wing wear and other measures for some birds. Ectoparasites were determined by K. C. Emerson (Smithsonian Institution, Washington), endoparasites by the late L. M. Angel (South Australian Museum), and food material determined by H. Aston (National Herbarium, Victoria), B. J. McHenry (South Australian Museum), B. Smith (Museum of Victoria), and J. Walker (Medical Parisitology Unit, Westmead Hospital, NSW).

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DISCOVERY OF A POPULATION OF THE RARE SCINCID LIZARD, *TILIQUA ADELAIDENSIS* (PETERS).

The scincid lizard *Tiliqua adelaidensis*, known as the Adelaide or pygmy bluetongue lizard, is probably the most enigmatic Australian reptile. It has been regarded as endangered if not extinct, with the last specimens being seen 33 years ago. We report here on the recent collection of specimens of *Tiliqua adelaidensis* which show that a wild population still exists. Discovery of this population will enable the gathering of the first data on the habits and ecology of this elusive lizard.

Tiliqua adelaidensis has been known from a total of only 20 specimens (G. Shea, pers. comm.) accumulated over 130 years. It was described as *Cyclodus adelaidensis* (Peters, 1863) from two specimens sent by Richard Schomburgk to the Berlin Museum, which holds five additional specimens. Other specimens found their way to the Natural History Museum, London (one), and the Naturhistorisches Museum, Vienna (three), while the South Australian Museum held eight specimens and the Museum of Victoria one.

The species was seldom mentioned subsequent to its description, and was apparently already very rare by the 1920's. Waite (1929) doubted that the species occurred in South Australia or even whether it was a distinct species and not a misidentified juvenile of one of the larger species. The species has been reported only twice this century. During the 1940s two specimens were donated to the S.A. Museum by a Burra resident, while the most recent sighting was at Marion, where two individuals were collected in October 1959 (both finds extensively discussed by Ehmann, 1982).

The extant specimens provide morphological information and some dietary data (Ehmann, 1982) but little else. In spite of Waite's doubts, the species is a valid but dwarfish member of the genus *Tiliqua*. Its dentition is distinctive (Shea & Hutchinson, 1992), the reduced dark patterning of scattered longitudinal series of irregular small blotches is unlike that of any other member of the genus and *T. adelaidensis* also shows weaker development of the specialised occipital and nuchal scalation typical of other, larger species in the genus. The diet assessed from preserved specimens appears to include both invertebrates and plant material (Ehmann, 1982).

A crucial deficiency has been the lack of any or adequate locality and habitat data accompanying the specimens. The few known localities extend from the Adelaide Plains and Mt Lofty Ranges northwards as far as Burra (Ehmann, 1982; Hutchinson, 1992; G. Shea, pers. comm.). About half of the specimens have no precise data, while some localities associated with specimens may be no more than addresses of the consigners of the specimens. All localities are from a small area of South Australia lying between the Adelaide Plains (Marion) and the North Mt Lofty Ranges (Burra). The type specimens were reportedly from 'stony, sandy terrain' but it is not clear whether they were collected near Schomburgk's property, Buchsfelde, west of Gawler, or from further afield. Meagre data accompanying specimens from Dry Creek railway station and Marion, both in Adelaide's suburbs, suggest a semi-fossorial way of life; at both localities the specimens were collected from cryptic retreats, under stones in the case of Dry Creek and from a burrow under a shed floor in the case of Marion. Unfortunately these localities are highly modified, revealing nothing of the species' natural habitat.

During the late 1960s to early 1980s vigorous attempts were made to relocate *T. adelaidensis* (partly documented by Ehmann, 1982). These attempts met with no success, and recent assessments of the species' status have been pessimistic. Prior to the discoveries reported here, it was becoming regarded as the the only one of over 700 Australian reptile species to have become extinct since European settlement (Wilson & Knowles, 1988; Hutchinson, 1992; Ehmann, 1992; Cogger, 1992). Extensive vegetation clearance, urbanisation, habitat modification generally and even mouse plagues have been blamed for the species' decline (Ehmann, 1982; 1992; Kennedy, 1990; Hutchinson, 1992).

The new specimens

The discovery of the population was made under unusual circumstances since the first specimens were found dead after having been taken by predators.

The first was collected on 14 October, 1992, by GA and JRWR while they were engaged in the joint Department of Environment & Land Managenment and South Australian Museum vertebrate survey of the South Olary Plains region. They collected a recently road-killed eastern brown snake (*Pseudonaja textilis*, Elapidae; SAMA R40688) which upon dissection in the field was found to contain a nearly perfect *Tiliqua adelaidensis* (R40687). The precise locality is obtainable from the South Australian Museum Herpetology Section, but is in the general vicinity of Burra, the area from which two of the previously collected specimens are known to have come.

R40689 was collected six days later, found freshly killed with still-bleeding neck and posterior head wounds. A group of three Australian kestrels (*Falco cenchroides*) inhabited the immediate vicinity of the discovery site and had a nest about 50 metres from where the body was found. The damage to the lizard is consistent with its having been caught and killed by

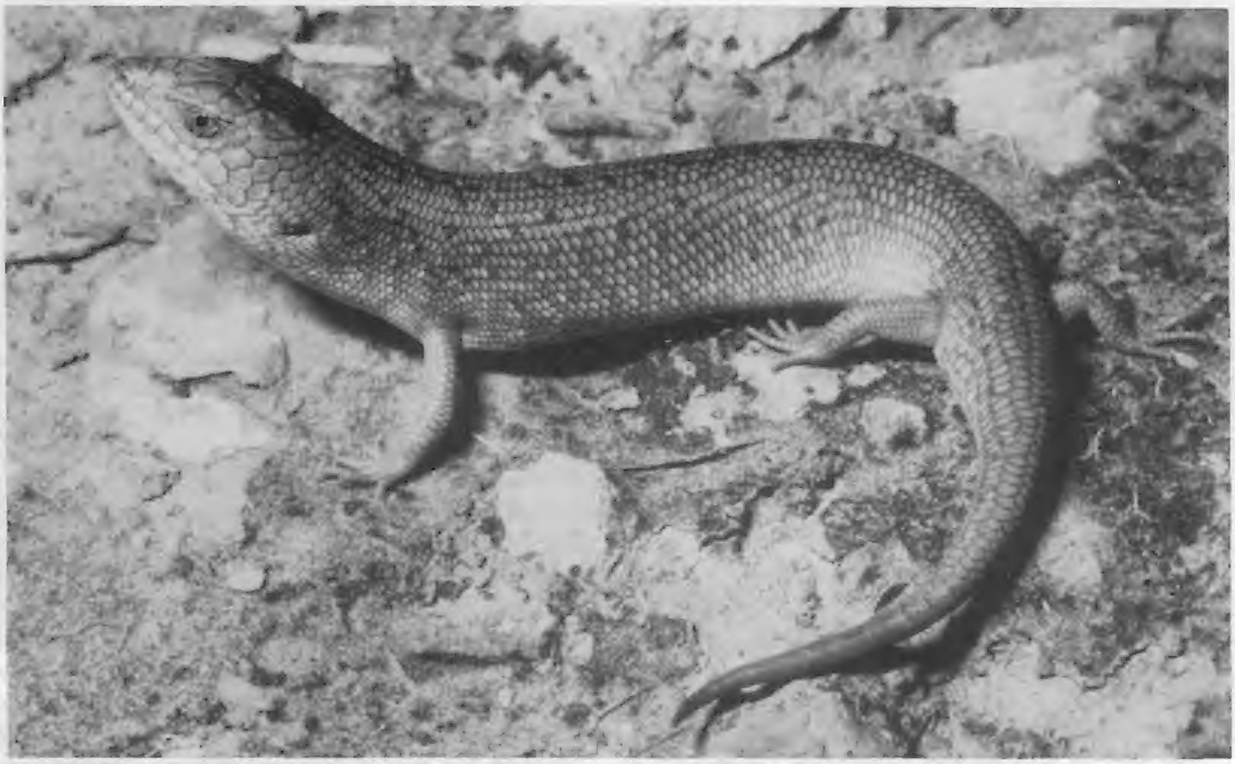

FIGURE 1. The first live specimen of *Tiliqua adelaidensis* from the newly discovered population. Snout-vent length of specimen 67 mm.

a kestrel (P. Horton, pers. comm.). This specimen was found approximately 8 km (air-line) from the site of the first. The third (R40728) and fourth (R40738) specimens were collected near the first. R40728 was found on 29 October, decapitated and partly eviscerated. Again this is consistent with the lizard having been taken by a bird of prey. R40738 was found on 4 November in the gut of another *P. textilis* which had been collected adjacent to the collection sites of R40687 and R40728.

The second, third and fourth finds were made in the course of establishing a pilot trapping study to ascertain if live specimens could be caught using conventional herpetological survey methods. This rapidly proved to be the case, with the first live male being caught in a pit trap on the afternoon of 6 November. The field study is continuing and further specimens have been found. The results of this work will be published shortly (Hutchinson & Milne, in prep.).

Discussion

A total of 18 additional reptile species have been collected from the immediate vicinity of the *T. adelaidensis* sites, with most species being recorded near more than one site, indicating similar ecological and faunal associations. Most notable are four species which are confined to or strongly associated with the Flinders Ranges-Mt Lofty Ranges area: *Ctenophorus decresii*, *Aprasia pseudopulchella*, *Delma molleri*, and an undescribed species of *Gehyra* (the 2n = 44 'variegata' of King, 1979). The long-term land use practices in the region have evidently allowed a significant number of reptile species to persist in spite of the almost complete elimination of the natural vegetation.

It is encouraging that *T. adelaidensis* has managed to survive in a far from natural habitat for a considerable time, although population size and current dynamics (declining, stable or increasing) are unknown. At this early stage, it is obviously not possible to reassess the conservation status of the species, and it should retain its 'endangered' classification. The pilot field study is intended as a first step, and must lead to more comprehensive surveys aimed at establishing the size and extent of the population, so that this species can be understood and its survival made secure.

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